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ABSTRACT

This teacher's guide to the Missouri auto body repair curriculum contains seven modules of instruction. Within each module are instructional units including some or all of the following components: performance objectives, information sheets, handouts, transparency masters, assignment sheets, job sheets, a unit test, and answers to the unit test. Special instructions needed to teach each unit are included in the notes to the instructor near the beginning of each unit. Student worksheets and references are also included. Learning activities and supplementary materials are suggested. The seven units cover the following topics: (1) introduction to auto body; (2) auto body welding; (3) panel repairs; (4) paint and refinishing; (5) exterior and interior trim; (6) mechanical services; and (7) frame-body and unibody construction and repair. (KC)

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Auto Body Repair Curriculum Guide

INSTRUCTOR'S GUIDE

MODULES:

- Introduction to Auto Body
- Auto Body Welding
- Panel Repairs
- Paint and Refinishing
- Exterior and Interior Trim
- Mechanical Services
- Frame-body and Unibody Construction and Repair

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Cover illustration courtesy of Chrysler Motors

AUTO BODY CURRICULUM

Instructor's Guide

Modules:

Introduction to Auto Body
Auto Body Welding
Panel Repairs
Paint and Refinishing
Exterior and Interior Trim
Mechanical Services
Frame-Body and Unibody Construction and Repair

Produced by the Instructional Materials Laboratory
10 Industrial Education Building
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FOREWORD

Once again, we are indebted to the teachers and administrators who provide their time, efforts and professionalism to develop curriculum for trade, technical and industrial education programs. This auto body guide is an outstanding example of what can be accomplished when the right people with the right attitude get together. The curriculum writers and subject matter experts who worked on this guide are to be commended for a job well done.

This guide's format has been set up for competency-based teaching and testing. Unit tests evaluate specific competencies and can be used with the Vocational Administrative Management System (VAMS). All components have been keyed to the auto body competency profile developed by industry and education professionals in the state.

Special appreciation is given to Roger Helms, who was the primary curriculum writer for the project. Special appreciation is also given to Harold Harden, Gil Hardin, Alan Polley and Don Roberts, who served as technical advisers and reviewers throughout the project, and who also wrote portions of some modules.

Although this guide may be a new format and new system in many classrooms, we are confident that, when used as designed, time spent by teachers and students will become more productive. Any future auto body curriculum modifications will begin with this guide. Auto body, like many technical fields, is undergoing constant and considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

Judith Perryman, supervisor
Industrial Education
Department of Elementary and Secondary Education

Steve Long, director
Industrial Education
Department of Elementary and Secondary Education

ACKNOWLEDGMENTS

This auto body guide represents a continuing commitment to Missouri's Vocational Instructional Management System (VIMS). The guide precisely follows the Auto Body Competency Profile developed by industry and education professionals in the state.

In developing this guide, every effort was made to provide the most up-to-date material possible. Four instructors from auto body programs in the state served through the entire project as technical advisers in the development of the instructional units by writer and editor Roger Helms. Those four individuals also contributing their skills as writers on some of the units. The four individuals: Harold Harden, Gil Hardin, Alan Polley and Don Roberts, are owed a great debt of gratitude for the many hours they contributed to the project.

While searching for current gas metal arc (MIG) welding materials for sources of information in the guide's development, helpful materials were found from the Mid-America Vocational Curriculum Consortium (MAVCC), of which IML is a member. MAVCC materials dealing with GMAW welding have been used extensively as a resource for some of the MIG welding portions of the Auto Body Welding Module in this guide.

Special recognition is also given to Jim Gaines and Ronald Downing, whose work as writers on IML's Auto Mechanics Curriculum Guide (1981) was adapted for this project's Module 6: Mechanical Services.

Another aspect of this guide's development is the adoption of Inter-Industry Conference of Auto Collision Repair (I-CAR) standards for unibody repair procedures. In order to fully instruct students in those standards, it is almost essential that auto body instructors participate in the I-CAR training program. While I-CAR standards are used in these materials, the I-CAR procedures can only be learned through the I-CAR training program. The curriculum guide is written with the assumption that the instructor using the guide has completed, or expects to complete, the I-CAR training program.

In addition, we gratefully acknowledge the following industry representatives and educators who contributed to the guide as members of advisory committees or who served as fieldtesters, using the guide in the classroom. We also gratefully acknowledge the companies who provided illustrations for the guide.

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Instructional Materials Laboratory
University of Missouri-Columbia

CONTENTS OF THIS GUIDE

Module 1: Introduction to Auto Body

Includes:
*Auto body careers
*Measuring and mixing
*Lifting and jacking
*Estimating
*Vehicle construction
*Tools and equipment
*Safety

Module 2: Auto Body Welding

Includes:
*Orientation and safety
*MIG welding
*Approved welds
*Types of auto body welding processes
*Oxyacetylene welding and cutting

Module 3: Panel Repairs

Includes:
*Sheet metal repair
*Plastic repair
*Panel replacement
*Corrosion protection
*Plastic body filler
*Fiberglass repair
*Bumpers
*Safety

Module 4: Paint and Refinishing

Includes:
*Orientation and safety
*Equipment
*Tinting and blending
*Paints and paint materials
*Spraying techniques
*Special paints

Module 5: Exterior and Interior Trim

Includes:
*Types of fasteners
*Stationary glass
*Vinyl tops and decals
*Moldings and trim
*Moveable glass
*Safety

Module 6: Mechanical Services

Includes:
*Air conditioning
*Lights
*Safety
*Cooling system
*Electrical systems

Module 7: Frame-body and Unibody Construction and Repair

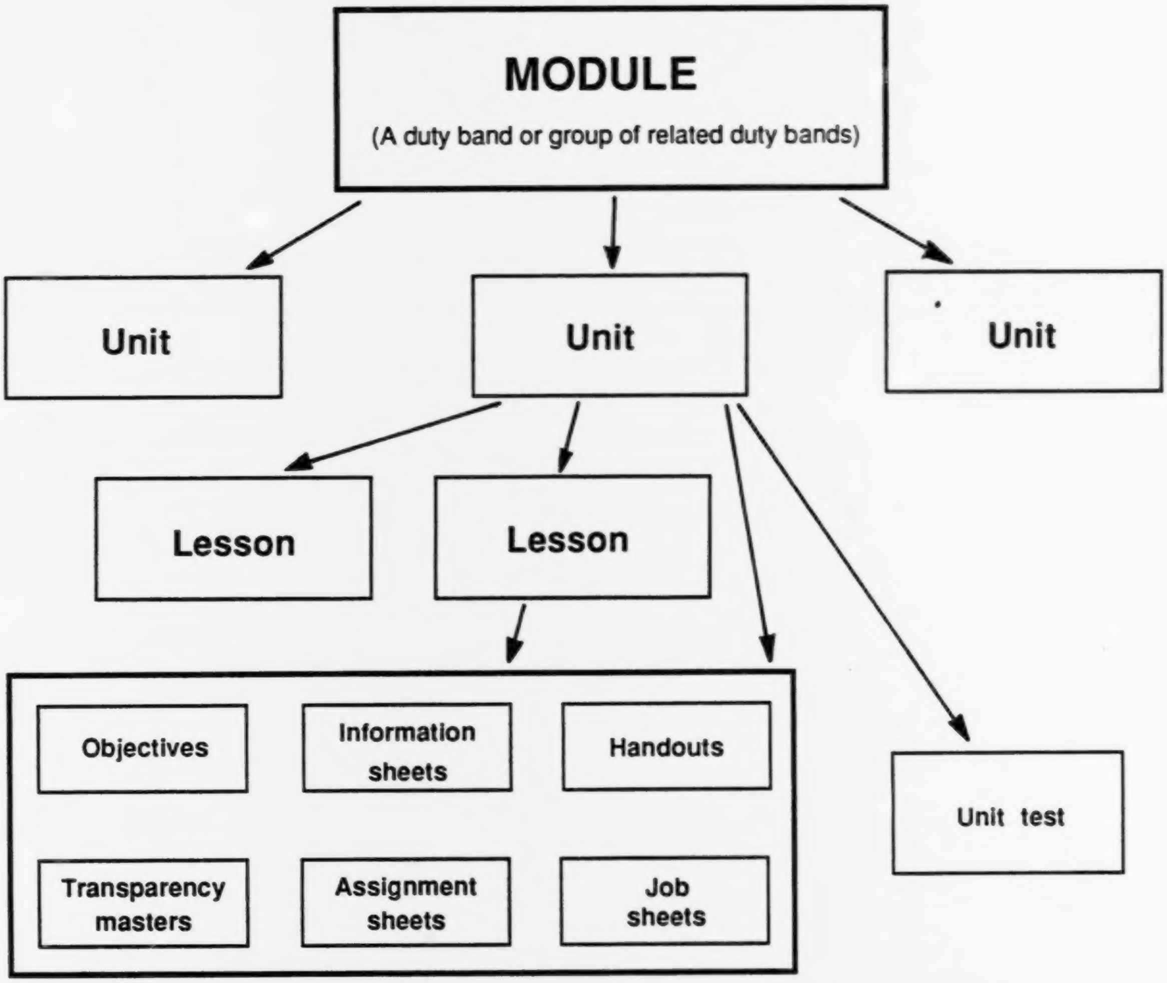
Includes:
*Safety
*Vehicle construction
*Frame equipment
*Repairing the unibody
*Steering and suspension
*Evolution of the unibody
*Repairing conventional frames

HOW TO USE THIS PUBLICATION

GUIDE COMPONENTS

Units of Instruction

This Auto Body guide contains seven modules of instruction. Within each module are instructional units including some or all of the following components: performance objectives, information sheets, handouts, transparency masters, assignment sheets, job sheets, unit test. Any special instructions needed to teach each unit are included in the Notes to the Instructor section near the beginning of each unit.


MODULE
(A duty band or group of related duty bands)
Unit
Unit
Unit
Lesson
Lesson
Objectives
Information sheets
Handouts
Transparency masters
Assignment sheets
Job sheets
Unit test

Objectives (color-coded white)

Each unit is based on performance objectives, which state what the student is expected to do and what degree of skill they must exhibit. Due to the need to allow local autotomy in each school, the performance level for the unit tests has been left blank. The instructor should tell the students what scores they will be expected to achieve, as determined by the local school district. Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the objectives' intent. Teachers should feel free to add/adapt objectives which will fit the material to student and community needs. Supporting material will, of course, need to be added for any new objectives.

Table of contents, references, notes to the instructor (pink)
These pages have been coded pink and are for instructor use only. The reference section lists materials used as sources in developing the unit. Special teaching instructions are included in the Notes to the Instructor section.

Information sheets (green)
Presented in outline form for clarity, these pages provide all the content essential for meeting the cognitive (knowledge) objectives in the unit. In this guide, the information has been presented as thoroughly as possible to provide the student the maximum means of understanding the material when studying on their own. Students should study the information sheets before class discussion.

Transparency masters (white)
Transparencies provide information by visually reinforcing or clarifying ideas presented in the information sheets. They are effective when identification is necessary and direct the class's attention to the topic of discussion. Transparencies should be left on the screen only when topics shown are under discussion, however.

Handouts (white)
Whenever it is desirable for the student to have a detailed illustration or supplemental information, a handout is used. Handouts give students additional information and are included in the student references. In some cases the instruction can also use these as transparency masters.

Assignment sheets (tan)
In most cases the assignment sheets furnish paper-and-pencil practice to develop the knowledge necessary as a prerequisite to skill development. They can be given to students for class completion or used as homework assignments. Answer sheets (color-coded pink) can be used by the student or instructor to check progress. In some instances the assignment sheet is used to evaluate a competency in cases where the student is required to determine the steps of procedure, or where a job sheet is too restrictive in scope.

Job sheets (blue)
These evaluation instruments are provided for two purposes: (1) to outline steps of procedure for mastering competencies, and (2) to evaluate the student's performance. Job sheets begin with a list of tools and materials needed for the activity. Job sheets furnish potential employers with a picture of skills being taught and of performance which might be reasonably expected from a vocational student.

Unit test (yellow)
Competency-based tests are designed to help eliminate subjective testing and to improve student evaluation and accountability. Specific competencies and test questions are linked on the test and answer key. These unit tests have been written to be used with VAMS (Vocational Administrative Management System), utilizing computer scan sheets for computer-recording of test answers. However, they have also been designed for use in programs without computerized grading. The unit test may be eliminated if the competency was thoroughly evaluated by job sheets. However, emphasis should be placed on cognitive as well as performance skills.

SUGGESTED ACTIVITIES

The following list of suggested activities may be helpful, especially to the beginning instructor.

1. Provide students with objective sheet and information sheets.
2. Discuss unit and specific objectives.
3. Discuss information sheets, assignment sheets and/or job sheets, lesson-by-lesson.
4. Have students do assignment sheet(s) to satisfactory levels.
5. Give students unit test.
6. After successful completion of the test, have students do job sheet(s).

Students should perform the following activities.

1. Read objective sheet.
2. Study information sheets.
3. Do assignment sheet(s).
4. Take unit test.
5. Do job sheets.

SUGGESTED SUPPLEMENTAL MATERIALS

The following is a list of supplemental text material which can be used with this guide. The guide is not designed for use with any specific text and many sources not listed may also make suitable supplemental materials.

Textbooks:

Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing*. Second edition. McGraw-Hill. New York, NY. 1986.

Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL. 1984.

Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

Scharff, Robert. *Motor Auto Body Repair.* Delmar Publishers, Inc. Albany, NY. 1988.

Toboldt, Bill. *Auto Body Repairing and Repainting.* The Goodheart-Willcox Co. Inc. South Holland, IL. 1982.

Training programs:

Blackhawk Automotive. *New Science of Unibody Repair.* Blackhawk Automotive. Milwaukee, WI. 1984.

Inter-Industry Conference on Auto Collision Repair. *Unibody Auto Collision Repair Training Program. (All segments).* Inter-Industry Conference on Auto Collision Repair. Des Plaines, IL.

AUDIO VISUAL MATERIAL AVAILABLE FROM THE MEDIA CENTER

The following is a list of audiovisual aids for auto body which have been developed by the Media Center, State Fair Community College, in Sedalia for the Missouri Department of Elementary and Secondary Education. The materials can be ordered by writing: The Media Center, State Fair Community College, 1900 Clarendon Road, Sedalia, MO 65301. Phone 816-826-7100.

1. Paint Safety in the Auto Body Shop (AB-82-100)
2. MIG Welding for Auto Body (AB-82-130)
3. Plastic Welding for Auto Body (AB-82-140)
4. Vocabulary and Terms of Basic Suspension Systems Used in Unitized Body Construction (AB-83-210)
5. Damage Analysis and Estimating (AB-84-220)
6. Measuring and Fixturing Techniques Used on Collision-Damaged Unibody Cars (AB-83-230)
7. Identification of High-Strength Steel and its Location in Unitized Body Construction (AB-83-240)
8. Rust Repair Methods (AB-83-260)
9. Front and Rear Alignment Systems (AB-83-270)
10. Rust or Corrosion Prevention by Application of Undercoating (AB-83-280)

PACKAGING

This Auto Body Guide has been packaged in three component parts: the instructor's guide, the student reference, and the student worksheets. For the teacher, the complete instructor's guide contains all seven modules, including all material for both the student and the teacher. Each of the seven modules has a separate, bound student reference, which includes the objective sheets, the information sheets and the handouts. Each of the seven modules also has a separate book of student worksheets, which includes assignment sheets, job sheets and unit tests. These worksheets have been padded in such a way that the instructor may separate the job sheets and assignment sheets from the tests, giving the former to the students and keeping the latter.

The student reference is designed to be reusable from year to year. The padded worksheets have been designed to be low cost, so that new student workbooks can be ordered as needed.

PAGE NUMBERING

The student reference and the student workbook both are numbered consecutively, from page 1 through the end of the material in each module. The pages of the instructor guide which are also in the student reference or student workbook have two page numbers on them. The page number at the top is the number in the instructor's guide, while the number at the bottom of the page is the number of the identical page in the student guide.

To assist in remembering this, the page numbers have the added designation of I (Instructor), S (Student reference), and W (student Workbook). In addition, each module carries a logical abbreviation of the unit. The abbreviations are as follows:

INTRO	(Module 1: Introduction to Auto Body)
WELDING	(Module 2: Auto Body Welding)
PANELS	(Module 3: Panel Repairs)
PAINT	(Module 4: Paint and Refinishing)
TRIM	(Module 5: Exterior and Interior Trim)
MECH	(Module 6: Mechanical services)
UNIBODY	(Module 7: Frame-body and Unibody Construction and Repair)

Thus, a page number of I-PANELS-22, means page 22 of the Instructor's guide of the Panel Repairs Module. Page S-TRIM-14, means page 14 of the Student Reference of the Exterior and Interior Trim Module. Page W-UNIBODY-44, means page 44 of the student workbook for the Frame-body and Unibody Construction and Repair Module. One page in the instructors guide, for example, might have the designation I-PAINT-114 at the top of the page and S-PAINT-62 at the bottom. The instructor will then know that this is page 114 of the Paint Module of the Instructor's guide, and the identical page in the student guide is 62.

This page numbering system has been developed so that the student materials are numbered consecutively, with no missing pages to be explained. At the same time, the system provides a means for the instructor to use only the instructor's guide and still know which pages in the student reference or student workbook correspond to the pages in the instructor's guide.

In the student reference and student worksheets, only one page number appears, at the bottom of the page.

COMPETENCY PROFILES

This guide is designed to be used with the Missouri Competency Profile for Auto Body. It is also designed to be used with the Vocational Administrative Management System. However, care has been taken to assure that the guide will also work in school systems which do not yet have VAMS in place. The specific objectives at the beginning of each unit clearly state which Missouri competency is being addressed and how it is being evaluated.

At the beginning of each module in the instructor's guide is a cross-reference chart, which matches the Missouri Competency to the information and evaluations. This has been done to assist the instructor in locating information on specific competencies. In addition, the objectives are keyed to competencies and evaluations on each objective page, and all evaluations are clearly keyed to competencies.

EVALUATION STANDARDS

This guide is designed so that local school districts can set performance standards on the written tests. The instructor, along with administrators, must determine what the standards will be. The students should be informed of the standards expected. The standards have been left blank on the unit objective and at the end of each test, or test portion. The instructor should have the students fill in these blanks with the determined performance standards.

UPDATING THIS GUIDE

Instructors are asked to assist in updating this guide by noting any mistakes, inconsistencies or missing information in the material. Instructors are invited to call the Instructional Materials Laboratory toll free in Missouri at 1-800-392-7217 with their suggestions for future changes.

IMPORTANT NOTE:

The techniques and procedures presented herein have been reviewed and approved by a technical advisory committee. However, each instructor is responsible for determining the appropriateness and safety of each procedure. The Job Sheets may have to be modified by the instructor to meet the procedural and safety requirements of the unique situations being encountered by the student. In addition, this guide assumes that the instructor will insure that manufacturer's recommendations have been provided and are being followed, both vehicle manufacturer's recommendations and equipment or material manufacturer's recommendations.

Auto Body Repair Curriculum Guide

INSTRUCTOR'S GUIDE

MODULE 1:

- Careers
- Vehicle Construction
- Measuring and Mixing
- Tools and Equipment
- Lifting and Jacking
- Safety
- Estimating

Introduction to Auto Body

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Cover illustration courtesy of Chrysler Motors

AUTO BODY CURRICULUM
Instructor's guide

MODULE 1:
INTRODUCTION TO AUTO BODY

Written by Roger Helms

Technical advisory committee:

Harold Harden, Gil Hardin, Alan Polley, Don Roberts

Produced by the Instructional Materials Laboratory
10 Industrial Education Building
University of Missouri-Columbia
Columbia, MO 65211
314/882-2884
July 1988

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Introduction to Auto Body

Cross-Reference Table of Instructional Materials

Competency	Unit	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
A 1	I	1-I, 1-II					1-15	
A 2	I	2-I, 2-II					16-51	
B 1	II	1-I, 1-II		1	1, 2		1-20	
B 2	II	1-III, 1-IV			2, 3		21-35	
C 1	III	1-III--1-IV					1-78	
C 2	III	2-I--2-III					79-98	
C 3	IV	1-I--1-IV					1-43	
C 4	IV	2-I--2-IV					44-90	
C 5	V	1-I-1V			1		1-30	
D 1	VI	1-I		1			44-47	
D 2	VI	1-II		1			1-10	
D 3	VI	1-III		1			21-33	
D 4	VI	1-IV		1			34-43	
D 5	VI	1-V		1			11-20	
E 1	VII	1-I--1-III			1		1-15	
E 2	VII	1-I--1-III		1	2		1-15	
E 3	VII	1-I--1-III		2	3		1-15	

MODULE: INTRODUCTION TO AUTO BODY

UNIT I: THE AUTO BODY AND THE AUTO BODY CAREER

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify opportunities in the auto body field and identify the basic construction of vehicles. Mastery will be evidenced by scoring ___________ percent on the appropriate portion of the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Identify opportunities in the auto body field (Competency A1, Part I of Unit I test)

II. Identify aspects of shop location and construction (Competency A1, Part I of Unit I test)

Lesson 2:

I. Match terms associated with vehicle construction to their correct definitions (Competency A2, Part II of Unit I test)

II. Identify vehicle body panels and construction (Competency A2, Parts II of Unit I test)

MODULE: INTRODUCTION TO AUTO BODY

UNIT I: THE AUTO BODY AND THE AUTO BODY CAREER

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

1. Lesson 1: The Auto Body Profession

   a. Information outline

2. Lesson 2: The Auto Body

   a. Information outline

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. In Unit IV of Module 7, "Frame-body and Unibody Construction and Repair," there is a much more in-depth look at vehicle construction, including the evolution of the unibody design and the use of high strength steels. Some instructors may wish to teach this information in the introduction to the course, or at least have the students look over the information sheets from Module 7, Unit IV.

B. The great variety of vehicle panels and the names for those panels can be confusing to students. The body panel discussion in Lesson 2 of this unit is an attempt to give the student an overview of the common panels found on most all vehicles. The lesson emphasizes that most vehicles have many more panels than the basic ones discussed in the lesson. The Chrysler "E" body illustrations (FIG. 1-5, FIG. 1-6) have been altered such that many small panels actally present on the "E" body are not shown.

REFERENCES USED IN WRITING THIS UNIT

1. Chrysler Motors. *Unibody Dimensions, Joints and Seams, All E Bodies.* Chrysler Training Programs. Chrysler Motors. Center Line, MI. 1986.

2. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

3. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL. 1984.

4. Inter-Industry Conference on Auto Collision Repair. Unibody Auto Collision Repair Training Program. *Unibody Structural Sectioning and Use of Recycled Parts.* Inter-Industry Conference on Auto Collision Repair. Des Plains, IL. 1984.

5. Mitchell Information Services, Inc. *Body and Mechanical Parts Service & Repair, Domestic Cars, 1981-85.* Mitchell Information Services. San Diego, CA. 1985.

6. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

7. Scharff, Robert. *Motor Auto Body Repair.* Delmar Publishers, Inc. Albany, NY. 1988.

8. Toboldt, Bill. *Auto Body Repairing and Repainting.* The Goodheart-Willcox Co. Inc. South Holland, IL. 1982.

MODULE: INTRODUCTION TO AUTO BODY

UNIT I: THE AUTO BODY AND THE AUTO BODY CAREER

LESSON ONE: THE AUTO BODY PROFESSION

I. **The auto body profession**

  A. Opportunities in the auto body field

    1. About one-fourth of the vehicles in use in the United States need some auto body repair work each year.

    2. There are an estimated 100,000 auto body and paint shops in the U.S. with about 200,000 body and paint technicians working in those shops.

    3. There is a shortage of qualified auto body technicians, allowing for immediate employment.

    4. Due to recent developments in the auto industry regarding new designs for vehicles, the need for qualified auto body technicians is expected to grow rapidly, particularly those with skills in unibody repair and plastic panel repair.

    5. The auto body technician is one of the more highly skilled and better paid specialists in the field.

    6. Auto body technicians are employed by auto dealer service shops, auto repair shops, fleet maintenance shops (government vehicles, trucks, busses, rental cars), and auto manufacturing plants.

    7. The major share of repair work continues to be done by small shops and the opportunities for self-employment are very good for up-to-date technicians.

    8. Auto body work is steady throughout the year and there is little likelihood of layoffs or shutdowns for auto body technicians.

  B. Jobs available in the auto body industry

    1. Shop manager

      a. Supervises day-to-day operations of shop

      b. Has understanding of every job performed in the shop

      c. Usually started out as an apprentice and worked up the ladder

      d. In small shops, the manager is usually the owner

    2. Shop foreman

      a. Supervises actual repair work

      b. Supervises repair technicians

c. In small shops, the foreman is usually the owner

3. Estimator

   a. Prepares written estimates for "bids" on body work

   b. Often started out as a repair technician

   c. Has one of the most important jobs in the shop

   d. In small shops, the estimator usually performs many jobs and may be the owner

4. Parts manager

   a. Orders parts for entire shop and keeps an inventory of materials on hand

   b. In small shops, the owner or foreman is usually the parts manager

5. Tow truck operator

   a. Operates tow truck to bring damaged vehicles to shop for temporary storage or repair

   b. Requires skill in operating truck and in correctly towing vehicles

   c. In small shops, the owner or foreman will be the tow truck operator

6. Body-repair technician

   a. Repairs or replaces sheet-metal, plastic and fiberglass parts on the car

   b. Apprentices will first learn this job

   c. Requires great skill and is the backbone job of the body shop

   d. In small shops, the owner may spend much of his time as a body-repair technician

7. Painting and refinishing technician

   a. Mixes paints, prepares or supervises preparation of surfaces to be painted, and applies paint

   b. Requires great skill in operation of spray gun and a thorough knowledge of refinishing procedures and refinishing products

   c. In many shops, the paint technician is also a body-repair technician

8. Power-equipment operator

   a. Operates complex frame-straightening equipment

   b. Requires knowledge of how to use equipment and how to make repairs

   c. In many shops, the repair technician is also a power-equipment operator

9. Upholsterer
   a. Replaces or restores worn or damaged upholstery and other interior trim
   b. Requires skill and thorough knowledge of upholstery repair and upholstery refinishing procedures
   c. In some small shops, the body-repair technician will perform routine jobs and the more difficult jobs will be sublet to an upholstery shop

10. Glass technician
   a. Installs new glass in the vehicle
   b. Requires skill and thorough knowledge of glass replacement techniques
   c. In some shops, glass installation is sublet to a glass specialty shop.

11. Office staff
   a. In larger shops, there may be one or more persons handling the volume of paperwork in the shop, including billing, paying bills, and record keeping.
   b. Requires some knowledge of accounting and the auto body business

C. The apprentice

1. The beginning auto body worker is usually hired as a helper or trainee.
2. High school education is preferred, with some emphasis on shop work, mechanical drawing, general mathematics and general science.
3. At the trainee level, people between 18 and 25 years of age with mechanical aptitude are usually preferred.
4. The apprentice will begin by working under the supervision of the body-repair technician and/or the paint and refinishing technician, performing such jobs as masking and sanding vehicles and applying and finishing body filler.
5. As the apprentice progresses, he or she will learn the skills to become a body-repair technician, paint technician, or both, and may also acquire skills as a power equipment operator and glass installer.
6. Three to four years of experience usually are required before the apprentice reaches the journeyman stage. During that period of the time, the apprentice will be expected to acquire his or her own set of hand tools.
7. In addition to auto body repair skills, the apprentice will learn skills with applications beyond auto body, such as MIG and oxyacetylene welding, and the use of power tools and equipment.

8. Workers generally are hired through newspaper advertisements, direct application, state employment offices, private employment agencies, vocational schools, unions, and personal recommendations.

D. Methods of pay for body repair technicians

1. Flat rate -- Technician gets a specified percentage of the labor charges paid by the customer, usually 40 to 60 percent.

2. Weekly guarantee plus flat rate -- Technician gets a fixed weekly base rate plus a specified percent of the labor charges.

3. Straight hourly rate -- General method of pay for trainees.

II. Body shop organization and requirements

A. The opportunity for self-employment is high in the auto body field.

B. In order to be self-employed, you must have a properly equipped shop.

C. Although a shop is a major investment, it is not as high, relative to the revenue generated, as that of other businesses.

D. Location and construction requirements for a body shop

1. Location should provide advertisement by being located along a heavily-traveled area

2. Building must be large enough for immediate needs. Building and land should be situated in such a way as to allow for future expansion.

3. The shop and the entrance to the shop should be kept attractive and professional-looking, free of clutter.

4. The building lot should have plenty of room for vehicle storage and there should be ample customer parking.

5. The floor plan should allow for as many panel repair areas as necessary, with one area for frame-straightening equipment, one area for paint-room preparation, and one paint room. Also, there should be enough room for storage, and adequate room for an office with enough room for customers and office staff to be comfortable.

6. The floor should be concrete, with several drains installed to allow the floor to be washed down.

7. In addition to the building and major equipment, much smaller equipment is needed, such as grinders, sanders, jacks, portable power jacks, a MIG welder and an oxyacetylene welder.

8. The office will need equipment. Most will be common items such as chairs, a desk, a typewriter, etc., but much time and effort can be saved by using a microfilm viewer for estimating purposes. Also, computerized estimating and parts ordering is beneficial for many shops.

MODULE: INTRODUCTION TO AUTO BODY

UNIT I: THE AUTO BODY AND THE AUTO BODY CAREER

LESSON TWO: THE AUTO BODY

I. **Auto body construction**

A. Terms and definitions

1. Body -- The assembly of structural and cosmetic panels, windows, doors and other parts that form the enclosures for the passenger compartment, engine compartment and luggage compartment.

2. Body panels -- Structural and cosmetic panels which are fastened together to form the vehicle body.

3. Chassis -- The configuration of steering and front- and rear-suspension systems, usually assumed to include everything except the body.

4. Frame -- The assembly of steel structural parts and sections that supports the engine and body and is in turn supported by the suspension.

5. Frame-body construction -- Vehicle construction in which a separate frame supports the suspension and drive train. The body is bolted to the frame. Also known as a conventional frame.

6. Present-day unitized -- Vehicle construction including the use of high-strength steel and energy-management design. Structural panels with complex bends are welded together to form a design that combines the body and frame.

   (Note: Although the finished product of present-day unitized construction is a 'one-piece' vehicle, the design is still composed of components that can be individually identified, and in most cases, individually repaired or replaced).

7. Unitized vehicle -- Refers to any unitized construction. Other terms employed are unit body, unit coupe, unicoupe, and unibody.

8. Unibody -- Refers to any unitized construction but is often used to refer to present-day construction, in which the frame and body can no longer be distinguished as separate units.

   (Note: The many terms for unibody construction often are used loosely. In all seven modules of this guide, 'unibody' will refer to present-day construction.)

B. Vehicles are constructed of two basic types

1. Frame-body vehicles (FIG. 1-1, next page)

   a. Older design, largely replaced by unibody

   b. Have a heavy frame that supports the suspension. Body panels are bolted to frame.

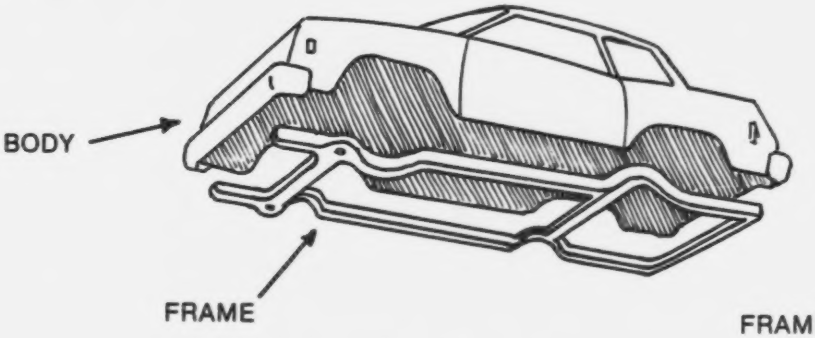
2. Unitized vehicles (FIG. 1-2)

    a. Modern design used for most vehicles built today

    b. Distinguished by not having a heavy frame separate from the body. Instead, relatively light body panels are welded together in such a way that the frame and body can no longer be distinguished separately.

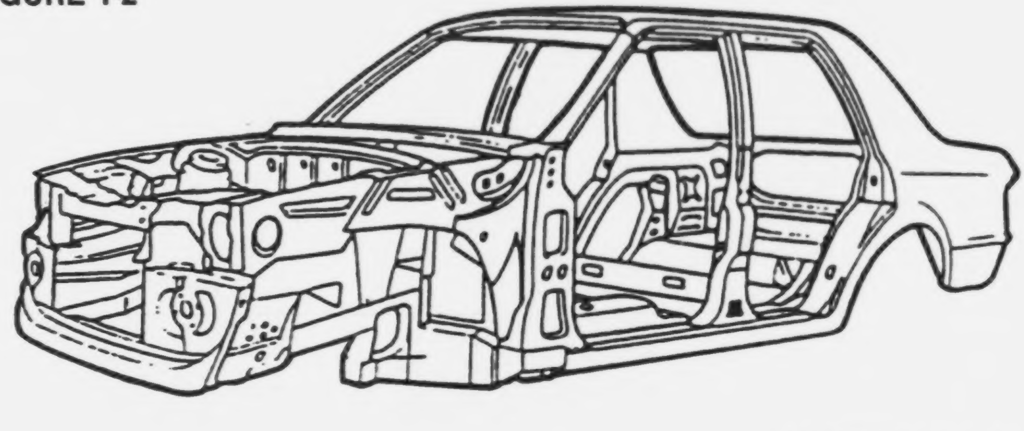
    c. The unitized vehicle has come to dominate the industry because it is lighter and more fuel-efficient than its frame-body counterpart.

FIGURE 1-1



FRAME-BODY VEHICLE

FIGURE 1-2



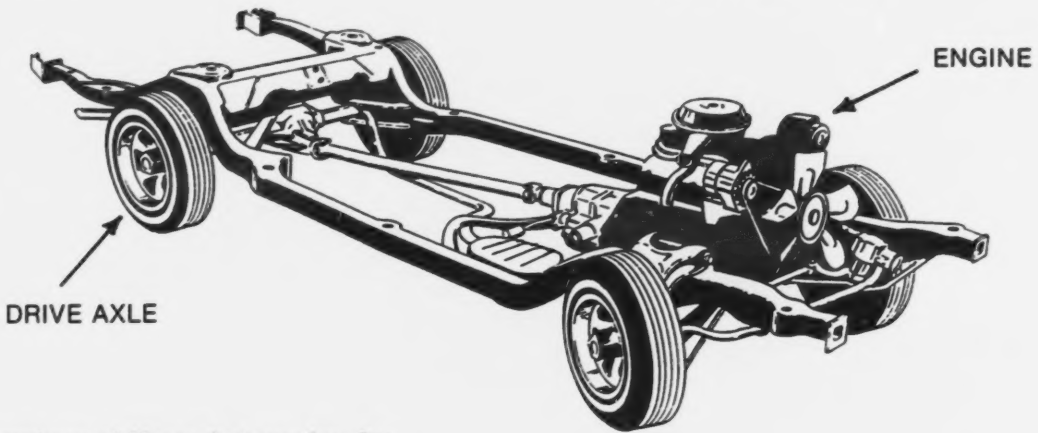
UNITIZED VEHICLE

Courtesy of Blackhawk Automotive, Inc.

C. Vehicles generally fall into several other primary classifications

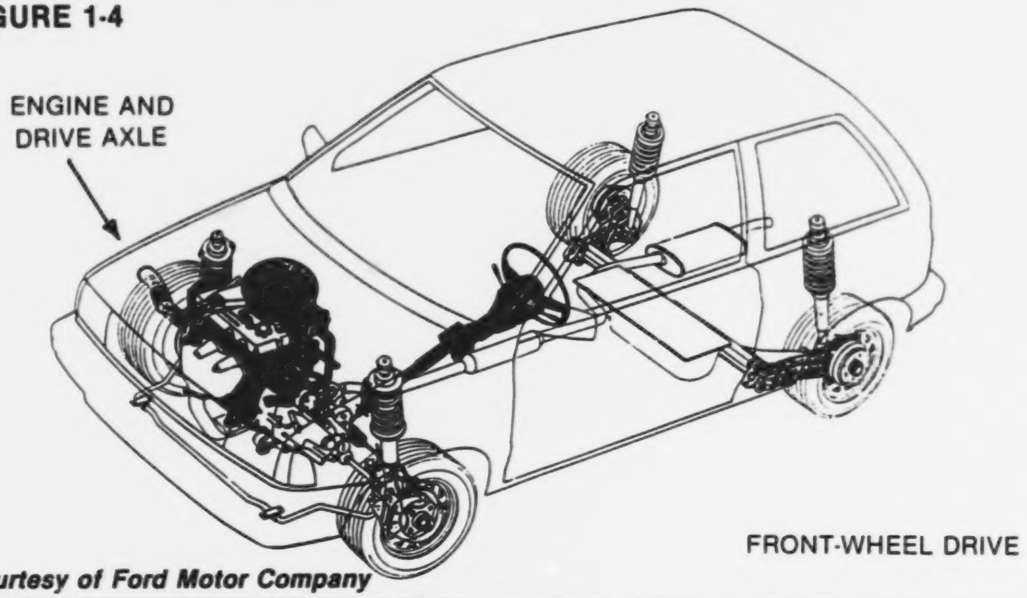
1. Front-wheel-drive or rear-wheel-drive (FIG. 1-3 and FIG. 1-4)

FIGURE 1-3


REAR WHEEL DRIVE
ENGINE
DRIVE AXLE

Courtesy of Moog Automotive, Inc.

FIGURE 1-4


ENGINE AND DRIVE AXLE
FRONT-WHEEL DRIVE

Courtesy of Ford Motor Company

2. Passenger carrier (car) or cargo carrier (truck)

3. There are various body styles on passenger cars, including two-door, four-door, hatchback, station wagon, van, utility vehicle, convertible, and limousine.

II. Body panels on the modern vehicle

(NOTE: Apprentice technicians will spend most of their time learning how to repair individual body panels.)

A. Body panels consist of all the vehicle's components which form the body, as opposed to those which form the frame (if present), engine, drive train, interior, or trim.

B. Panels generally carry the same names and locations for both frame-body and unitized vehicles. The main exceptions are that unitized vehicles will also have front- and rear-body rail assemblies.

C. The auto body technician must know the location and function of all body panels.

(NOTE: What follows is an example of basic body panels for a unitized vehicle. On an actual vehicle, many more small panels will be found. These panels are not discussed thoroughly because of the variety of constructions and terminology.)

D. Location of primary unibody structural panels often needing repairs (FIG. 1-5, next page).

E. There are seven principle structural components of the modern unibody vehicle which are frequently involved in repairs. Although many panels contribute to the vehicle strength, these seven components are critical to maintaining the strength of the unibody vehicle.

1. Front rails -- Extend forward from under the floor pan toward the front the vehicle.

   (NOTE: Front rails may include upper and lower rails and an apron/strut tower assembly, which is the attachment point for the suspension.)

2. Rocker panels -- Form the lower exterior edge of the passenger compartment.

3. Rear rails -- Extend back, beneath the floor pan, toward the rear of the vehicle.

4. B-pillars -- Extend from the center of the rocker panel upward along the outside edge of the passenger compartment. The B-pillar is often referred to as two panels - the top portion called the center pillar and the bottom portion called the door-lock pillar.

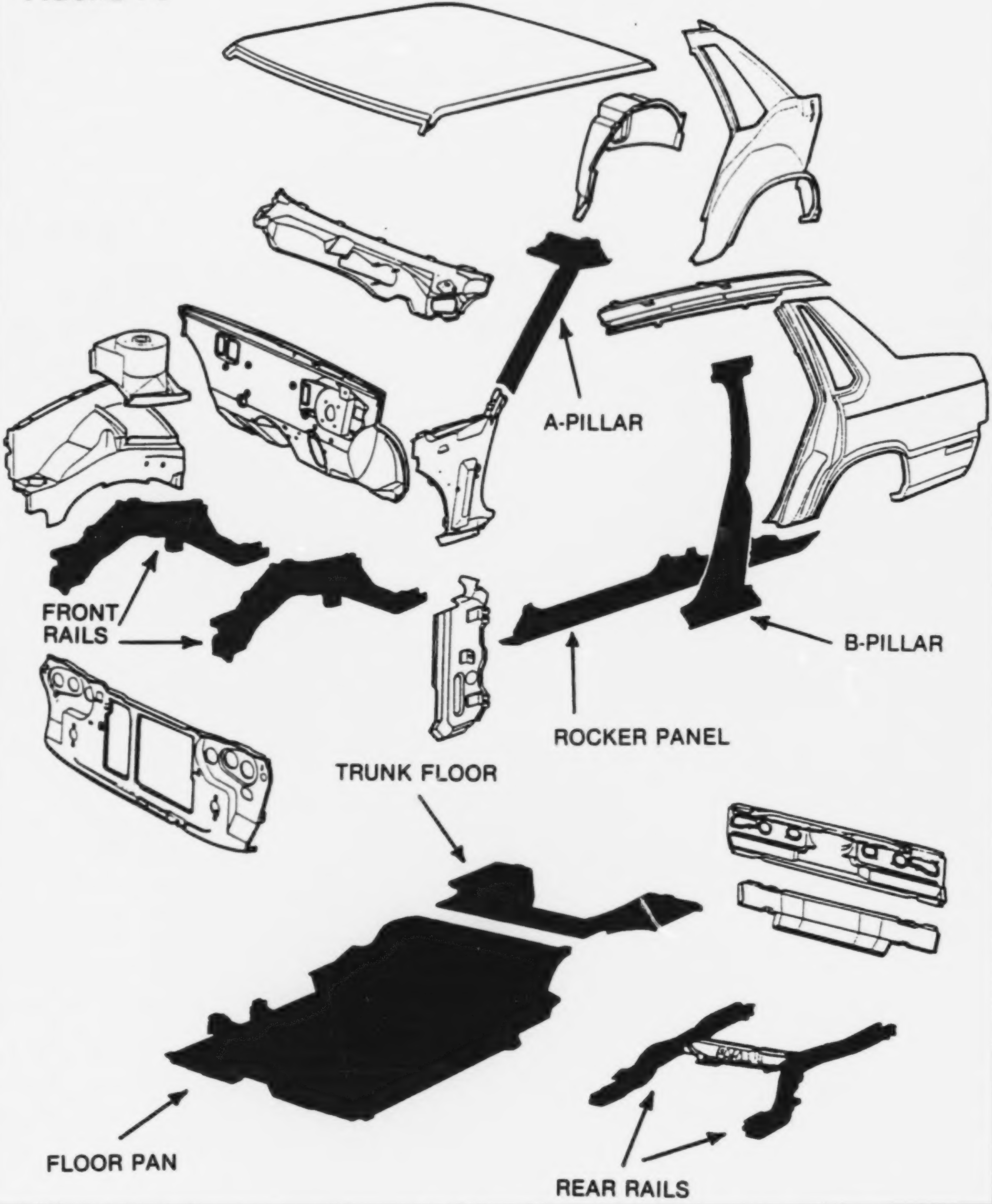
5. A-pillars -- Extend upward from the front of the passenger compartment and form the outer edge of the windshield area. The A-pillar often referred to as two panels - the top portion called the windshield pillar and the bottom portion called the front-hinge pillar.

6. Floor pans -- Form the bottom of the passenger compartment, extending between the right and left rocker panels.

7. Trunk floors -- Form the bottom of the rear compartment, extending between the rear rails and adjoining the floor pan.

   (NOTE: Great care must be taken when repairing these structural components.)

FIGURE 1-5


A-PILLAR
FRONT RAILS
B-PILLAR
ROCKER PANEL
TRUNK FLOOR
FLOOR PAN
REAR RAILS

Adapted with permission of Chrysler Motors

F. Location of other principle body panels (FIG. 1-6, next page)

1. Inner fender assemblies -- Form a bridge between the front rail assembly and the fender. They provide the upper attachment point for the fender and also serve to keep road hazards and water out of the engine compartment.

   (NOTE: Inner fender panels come in a variety of designs with a variety of names. In many cases, several smaller panels are welded or bolted together to form the inner fender assembly. The apron-strut tower assembly, providing the attachment for MacPherson-strut-type suspensions, may be referred to as either a frame rail assembly or an inner fender assembly.)

2. Radiator support -- Forms the connecting link between the front fenders and provides an attachment point for the fascia assembly and the radiator assembly.

3. Firewall -- Forms the barrier between the passenger compartment and the engine compartment and is welded to the floor pan along the bottom edge and to the A-pillars on each side. Sometimes called the lower cowl panel.

   (NOTE: The firewall is a principal structural panel that greatly contributes to the vehicle strength. However, the firewall is seldom involved in repairs, since a collision severe enough to damage the firewall usually totals the vehicle.)

4. Cowl panel -- Connected to firewall at top and extends between windshield and hood opening. Sometimes called the upper cowl panel.

5. Header bar -- Forms the front edge of the roof panel and is welded to the top of the windshield pillars.

6. Roof panel -- Forms the covering over the passenger compartment.

7. Roof side panels -- Form the sides of the roof panel and provide strength for the roof panel.

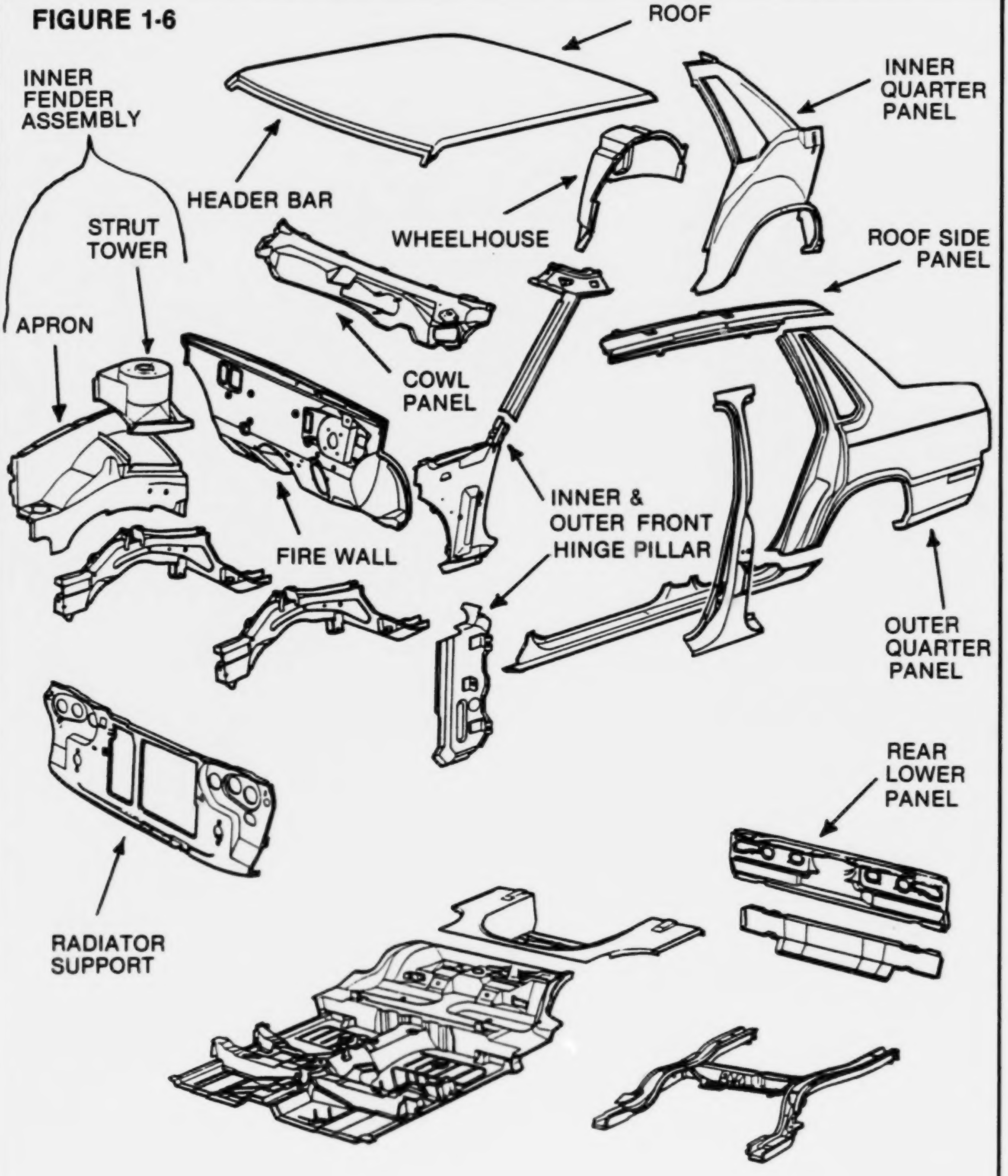
8. Outer quarter panels -- Form the exterior rear "quarters" of the vehicle, extending from the roof panel and rocker panel backward and forming the edge of the deck (trunk) opening.

9. Inner quarter-panel assemblies -- Form the inner portion of the quarter-panel assembly, which includes the inner and outer wheel-housing panels and may include one of more smaller panels of various names. The purpose of the inner quarter-panel assembly is to provide a shield against road hazards and water for the inside of the quarter panel and the inside of the trunk compartment.

10. Inner and outer front hinge pillar -- Attaches between the windshield pillar (A-pillar) and the rocker panel and the firewall. It provides the attachment point for the door.

11. Rear lower panel -- Forms the rear of the vehicle, being welded to the trunk floor along the bottom edge and the quarter panels on the sides. Usually provides the attachment points for the taillights. The rear lower panel is often composed of several smaller panels with a name for each of the smaller panels.

FIGURE 1-6


ROOF
INNER FENDER ASSEMBLY
INNER QUARTER PANEL
HEADER BAR
WHEELHOUSE
STRUT TOWER
ROOF SIDE PANEL
APRON
COWL PANEL
INNER & OUTER FRONT HINGE PILLAR
FIRE WALL
OUTER QUARTER PANEL
REAR LOWER PANEL
RADIATOR SUPPORT

NNER

Adapted with permission of Chrysler Motors

G. Location of commonly damaged exterior body panels (FIG. 1-7)

(NOTE: Although the following panels may contribute to the strength of the vehicle, they are usually considered cosmetic panels.)

1. Fenders -- Form the exterior covering around the front wheels.

   (NOTE: "Fender" usually refers to front panels. Rear panels covering the rear wheel area are known as quarter panels. An exception to this is the Pontiac Fiero, which has a large wrap-around rear fascia and a small "fender panel.")

2. Hood -- Forms the covering over the engine compartment and can be raised and lowered to gain access to the engine compartment.

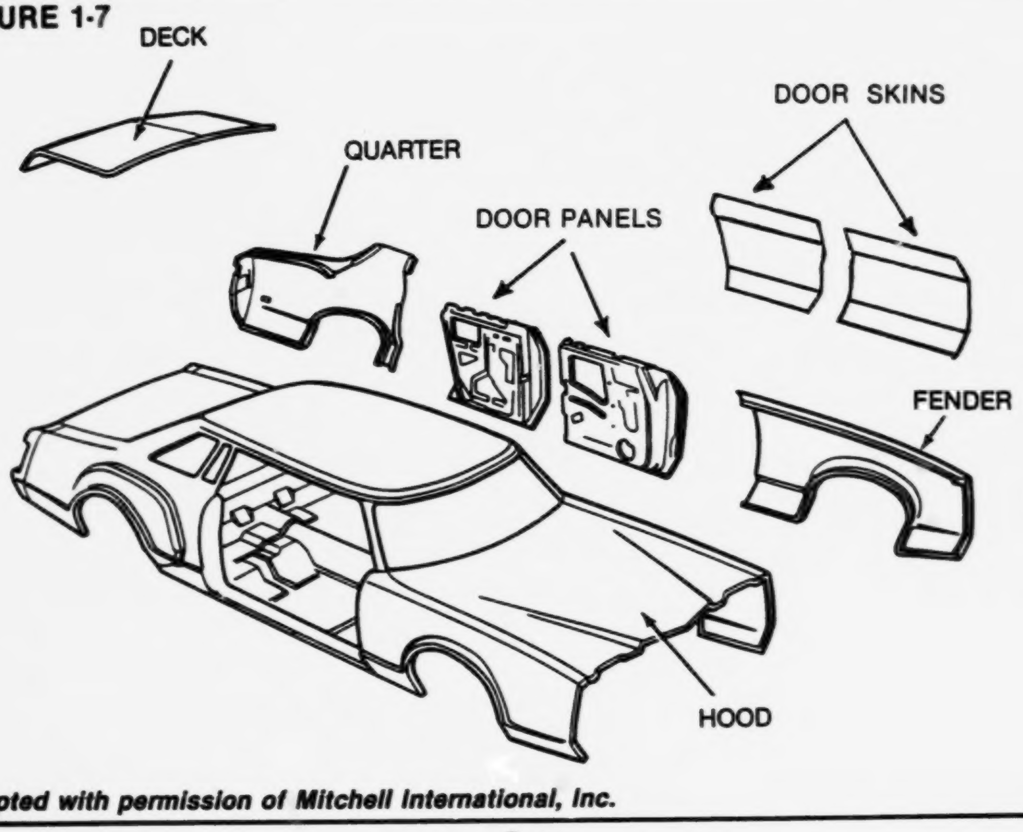
3. Outer door panels -- The exterior covering over the inner door panel. The outer door panel is usually referred to as the "door skin."

4. Inner door panels -- The movable panels that form the framed assemblies which cover the door openings and house the window and window regulator assemblies.

5. Outer quarter panels -- Form the exterior rear "quarters" of the vehicle.

6. Deck lid (trunk lid) -- Forms the covering over the trunk compartment and is movable, allowing access to the trunk compartment.

FIGURE 1-7

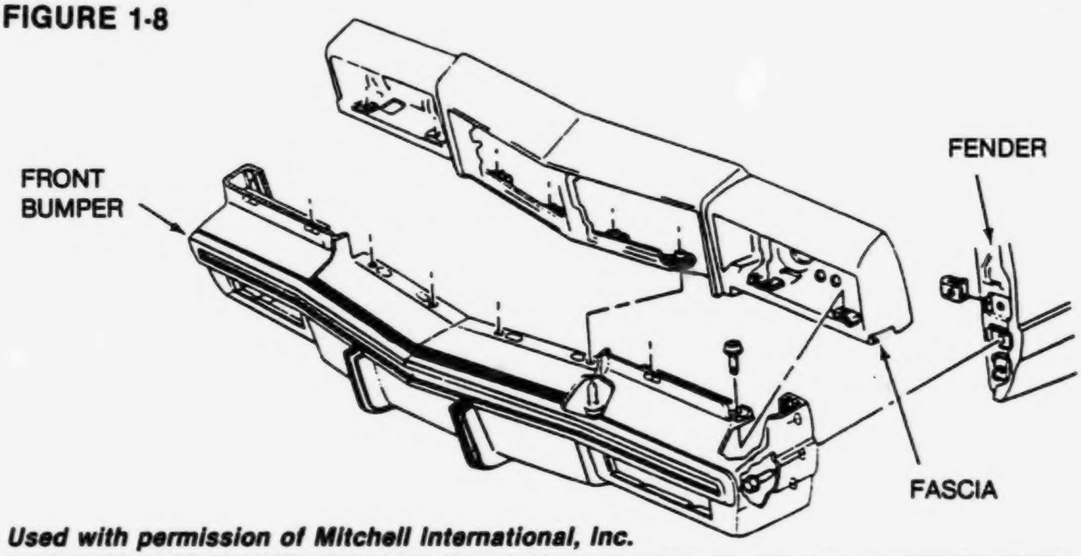


Adapted with permission of Mitchell International, Inc.

H. Bumpers and fascias (FIG. 1-8)

1. Two other panels which are very often damaged in collisions are bumpers and fascia assemblies.

FIGURE 1-8



Used with permission of Mitchell International, Inc.

2. Front and rear bumpers -- The heavy bar-type panels that form a protection for the front and rear of the vehicles and are connected to the front and rear body rails (or frame for frame-body vehicles). The bumper is usually divided into a face bar (the outside portion) and a support bar (the inside portion).

3. Fascia -- The cosmetic front of the vehicle which attaches to the radiator support and the fenders. The fascia may be composed of several cosmetic panels, although many modern vehicles are using a one-piece soft fascia of molded rubber or plastic over an inner reinforcing panel. In addition to cosmetic purposes, the fascia's functions include providing an air passage into the engine compartment (grille), providing a housing for the headlight and parking light assemblies, and providing additional collision protection for the engine compartment.

   (NOTE: In some vehicles there is a cosmetic rear fascia in addition to a front fascia.)

I. Components in addition to body panels

(NOTE: Although the auto body technician is mainly concerned with repairing panels, he must have knowledge of all the rest of the vehicle components, since they may have to be repaired, replaced or adjusted due to damage to panels.)

1. Engine and drive train

  a. Consists of the engine, transmission and drive axle assemblies

  b. Although engine and drive train *repair work* is not the job of the auto body specialist, the auto body technician must be able to remove and replace engine and drive train components, and also be able to recognize damage to those components.

2. Suspension and steering

   a. Consists of all the components which form the means for supporting the weight of the vehicle on the wheels and allowing for steering

   b. Due to the unibody vehicle's construction, the auto body technician must now be able to diagnose and repair many suspension and steering problems.

      (NOTE: See Module 7 "Frame-Body and Unibody Construction and Repair," for a detailed discussion of suspension and steering systems.)

3. Interior components and trim

   a. Consists of the dash assembly, seats, door interior trim panels, headliner, carpet, seatbelts and other interior trim components

   b. The body repair technician must know how to remove and replace these items, which are often damaged in a collision, and in some cases be able to repair them.

      (NOTE: See Module 5 "Exterior and Interior Trim," for a detailed discussion on interior trim.)

4. Exterior trim

   a. Consists of the all the items attached to the exterior vehicle panels, which enhance the appearance of the vehicle or provide convenience or protection to the driver

      (Examples: Name plate, emblem, decals, side moldings, rearview mirror, radio antenna, windshield, window glass.)

   b. The body repair technician must know how to remove and replace these items, which are often damaged in a collision, and in some cases repair them.

      (NOTE: See Module 5 "Exterior and Interior Trim" for a detailed discussion on exterior trim).

MODULE: INTRODUCTION TO AUTO BODY

UNIT I: THE AUTO BODY AND THE AUTO BODY CAREER

UNIT I TEST

PART I–THE AUTO BODY CAREER

I. Mark a T on the test or the answer sheet if the statement is true and an F if the statement is false.

_____1. The need for qualified auto body technicians has been decreasing.

_____2. Due to recent developments in the auto body field there is a great opportunity for auto body workers with skills in unibody repair and plastic repair.

_____3. The auto body technician is one of the more highly skilled and better paid specialists in the automotive field.

_____4. Only a small portion of auto body repair is being done by small shops.

_____5. One concern of auto body workers is that they may not have employment all year.

_____6. The shop manager must have an understanding of every job performed in the shop.

_____7. The estimator has one of the least important jobs in the auto body field.

_____8. Apprentices first will learn how to repair and replace sheet-metal, plastic and fiberglass panels.

_____9. The paint and refinishing technician must have great skill in using a spray gun.

_____10. In hiring an apprentice auto body technician a high school education is preferred, with emphasis on shop work, mechanical drawing, mathematics and general science.

_____11. Three to six months of experience is usually required before the apprentice reaches the journeyman stage.

_____12. In a flat-rate pay scale, the auto body worker gets a certain hourly wage for each hour worked.

_____13. A body shop should be located in a less-traveled area to reduce the possibility of theft and vandalism.

_____14. The body shop and entrance should be full of vehicles and vehicle parts so that people will know you are a busy and popular shop.

_____15. The floor of a body shop should be concrete with several drains so that the floor can be washed down.

(NOTE: Completion of this portion of the unit test is the evaluation for Competency A1 "Identify opportunities in the auto body field." Of the 15 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this portion of the test.)

PART II–THE AUTOMOBILE BODY

I. Match the terms in the right column with the most closely associated definition in the left column.

_____16. The assembly of structural and cosmetic panels, windows, doors and other parts forming the passenger compartment, engine compartment and luggage compartment

_____17. Vehicle construction in which the body and frame are no longer separate units

_____18. The configuration of steering and front and rear suspension systems, usually assumed to include everything except the body

_____19. Vehicle construction in which the body is bolted to a separate frame

_____20. Structural component which forms the lower exterior edge of the passenger compartment

_____21. Extends from under the floor pan forward toward the front of the vehicle

_____22. Extends from under the floor pan backward toward the rear of the vehicle

_____23. Extends from the center of the rocker panel upward

_____24. Extends upward from the front of the passenger compartment, forms outer edge of windshield area

_____25. Forms the bottom of the passenger compartment

_____26. Forms the bottom of the rear compartment

A. Rear rail

B. Frame-body

C. Trunk floor

D. Chassis

E. Rocker panel

AB. Unibody

AC. Front rail

AD. Floor pan

AE. A-pillar

BC. B-pillar

BD. Header bar

BE. Body

II. Match the panels in the list below with their correct location on the illustrations below.

_____27. Door skin

_____28. Quarter panel

_____29. Strut tower

_____30. Roof panel

_____31. Radiator support

_____32. Fender

_____33. Firewall

_____34. Front rail

_____35. Hood

_____36. B-pillar

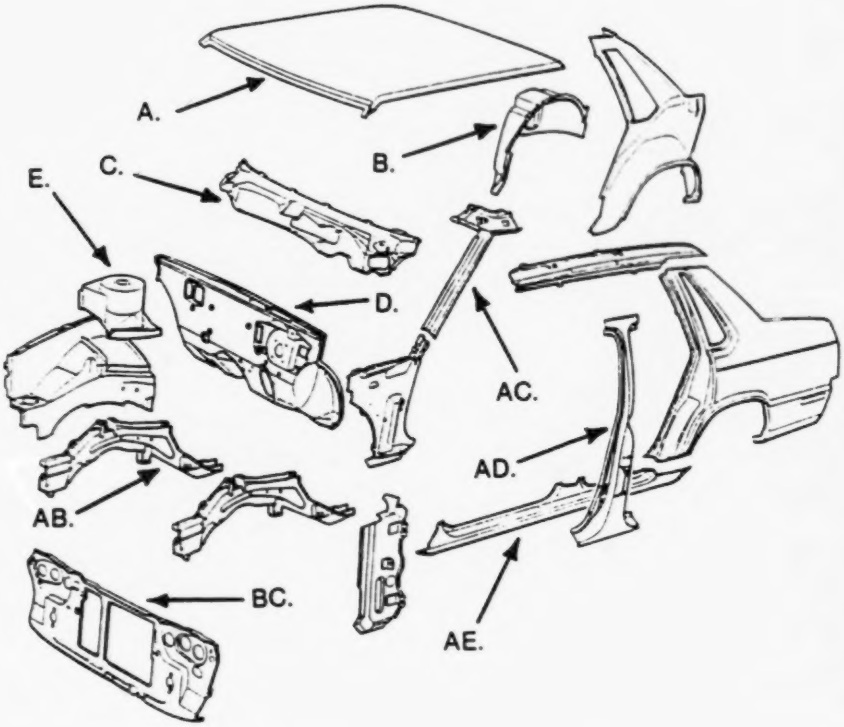
_____37. Rocker panel

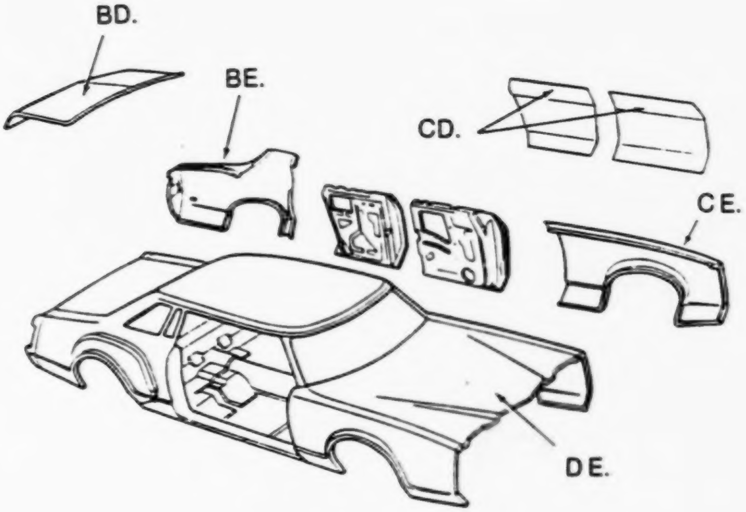
_____38. Deck lid

_____39. Cowl panel

_____40. Wheel housing

_____41. A-pillar





III. Mark a T on the test or the answer sheet if the statement is true and an F if the statement is false.

_____42. Frame-body construction is an older vehicle design.

_____43. The unibody vehicle has come to dominate the automobile industry because it is lighter and more fuel-efficient than older designs.

_____44. The cowl panel is the attachment point for the suspension on many unibody vehicles.

_____45. The A-pillar is often broken into two panels, referred to as the center pillar and the door lock pillar.

_____46. The B-pillar is often broken into two panels, referred to as the front hinge pillar and the windshield pillar.

_____47. The auto body technician must be able to remove and replace engine and drive-train components.

_____48. The auto body technician does not need to know how to diagnose and repair suspension and steering problems.

_____49. The auto body technician must be able to remove and replace interior trim components.

_____50. The exterior trim of a vehicle includes such things as the grille and the decals.

_____51. The firewall is a structural panel.

(NOTE: Completion of this portion of the unit test is the evaluation for Competency A2 "Identify vehicle body panels." Of the 36 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this portion of the test.)

ANSWERS TO UNIT I TEST

PART I

1. F
2. T
3. T
4. F
5. F
6. T
7. F
8. T
9. T
10. T
11. F
12. F
13. F
14. F
15. T

PART II

16. BE
17. AB
18. D
19. B
20. E
21. AC
22. A
23. BC
24. AE
25. AD
26. C

27. CD
28. BE
29. E
30. A
31. BC
32. CE
33. D
34. AB
35. DE
36. AD
37. AE
38. BD
39. C
40. B
41. AC

42. T
43. T
44. F
45. F
46. F
47. T
48. F
49. T
50. T
51. T

MODULE: INTRODUCTION TO AUTO BODY

UNIT II: MEASURING AND MIXING

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to read both a metric and fractional inch rule, and solve problems involving volume and ratios. Mastery will be evidenced by scoring __________ percent on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Read a fractional-inch rule (Competency B1, Part I of Unit II test)

II. Read a metric rule (Competency B1, Part I of Unit II test)

III. Solve problems involving ratios (Competency B2, Part II of Unit II test)

IV. Solve problems involving percentages (Competency B2, Part II of Unit II test)

MODULE: INTRODUCTION TO AUTO BODY

UNIT II: MEASURING AND MIXING

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

  1. Lesson 1: Measuring and Mixing

    a. Information outline

    b. Handout

      HO#1: Measuring in the Auto Body Profession

    c. Assignment sheets

      AS#1: Read a fractional inch rule
      AS#2: Read a metric rule
      AS#3: Solve problems involving ratios and percentages

    d. Answers to assignment sheets

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. The four assignment sheets are almost identical to the unit test. The students should do the assignment sheets and discuss them in class prior to taking the test.

B. Instructors should consider designing their own assignment sheets which have the students do measuring and mixing in shop situations.

REFERENCES USED IN WRITING THIS UNIT

1. du Pont, E.I. *Auto Refinishing Handbook*. E.I. du Pont de Nemours & Co. Wilmington, DE. 1985.

2. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair*. Second edition. Bennett Publishing Company. Peoria, IL 1984.

MODULE: INTRODUCTION TO AUTO BODY

UNIT II: MEASURING AND MIXING

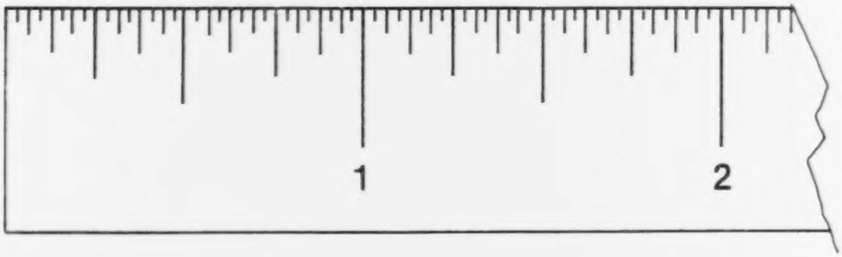
LESSON ONE: APPLIED AUTO BODY MEASURING

(NOTE TO THE STUDENT: Read the handouts on pages S-27 and S-28 of this unit. The handouts contain valuable information for understanding the lesson.)

I. **Reading a fractional-inch rule**

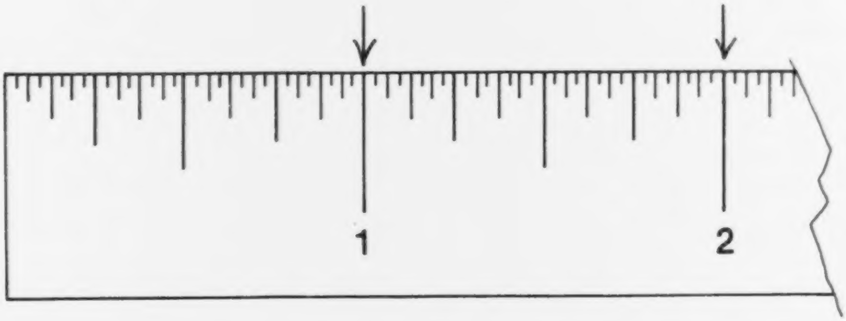
A. The fractional inch rule divides each inch into 32 marks, with marks of different heights

B. The lower the height of the mark, the less distance is being measured.



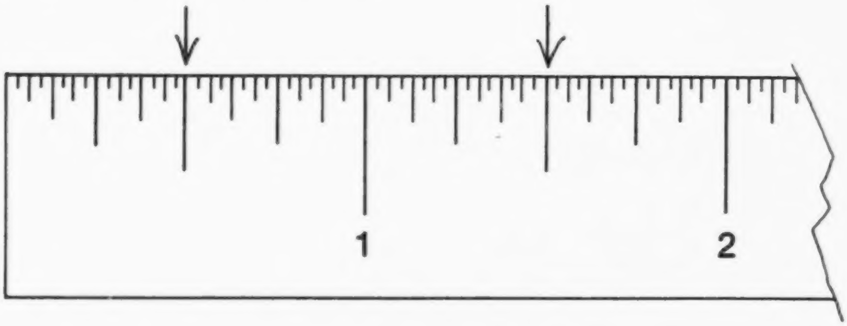
C. The divisions on a fractional-inch rule

1. Inches

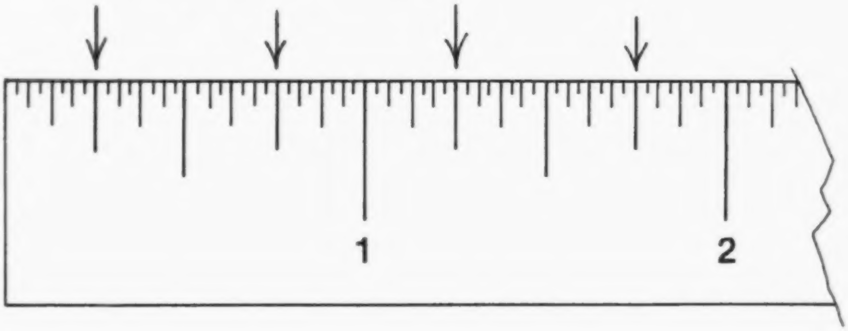


44

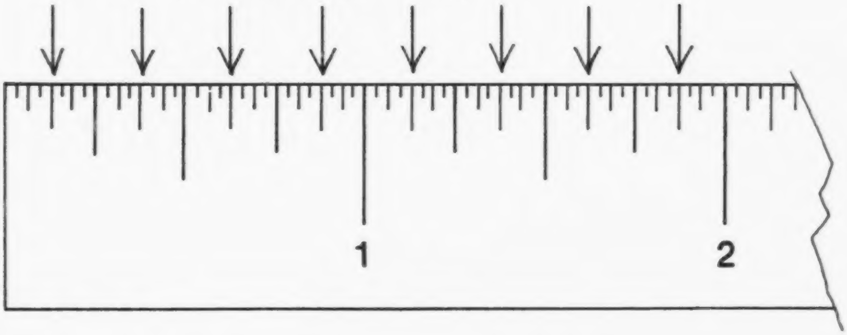
2. Half-inches (One-half of an inch)



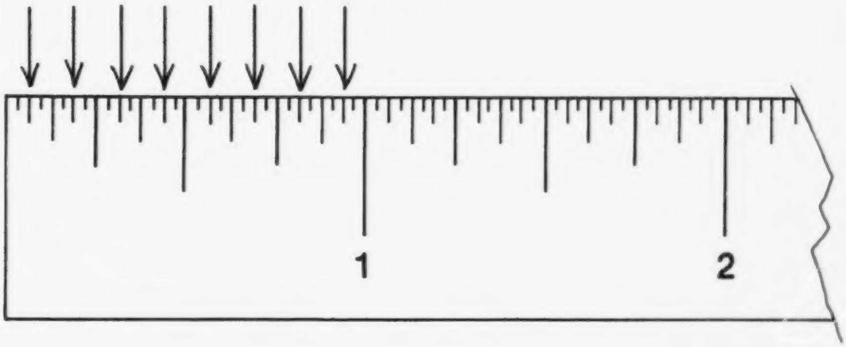
3. Quarter-inches (One-half of a half-inch)



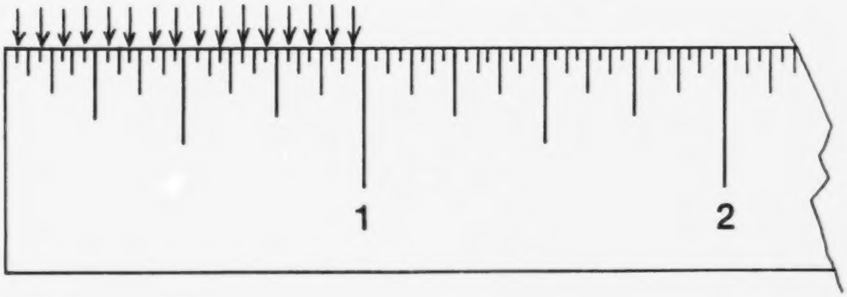
4. Eighth-inches (One-half of a quarter-inch)



5. Sixteenth-inches (One-half of an eighths-inch)



6. Thirty-secondth-inches (One-half of a sixteenth inch)



E. Adding and subtracting fractions

1. Fractions are always expressed as one number over another, with the top number called the numerator and the bottom number the denominator.

2. In order to add or subtract fractions the denominators must be the same. Once the denominators are the same, the numerators are added together.

   Example: To add 7/16 and 3/8, the 3/8 must be converted to 16ths. Therefore, multiply 3/8 by 2:

   2 × 3/8 = 6/16. *7/16 + 6/16 = 13/16.*

3. Adding or subtracting fractions derived from a fractional-inch rule is relatively easy because the limited number of fractions used are easily converted into the same denominators.

F. Dividing fractions in half

1. In auto body work, often it is necessary to divide a measurement in half, and this may involve fractions. Dividing fractions is done simply by multiplying the denominator by 2.

Example: One-half of 1/4 is 1/8 (The numerator is kept the same while the denominator is multiplied by two). One half of 3/16 is 3/32.

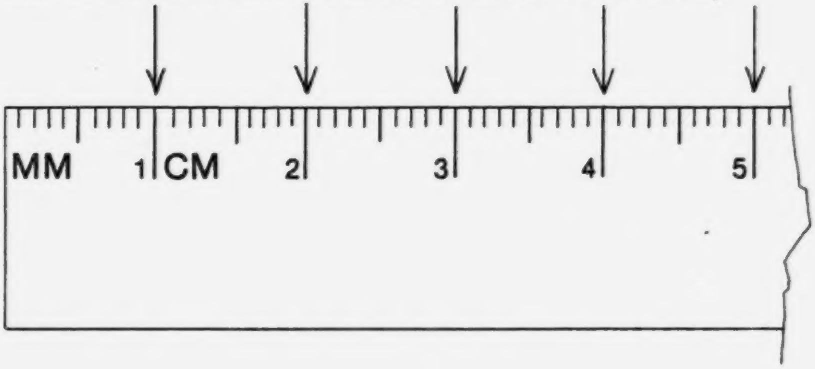
II. Reading a metric rule

A. Reading a metric rule requires careful attention to the rule marks, but working with metric numbers is easier than working with fractions.

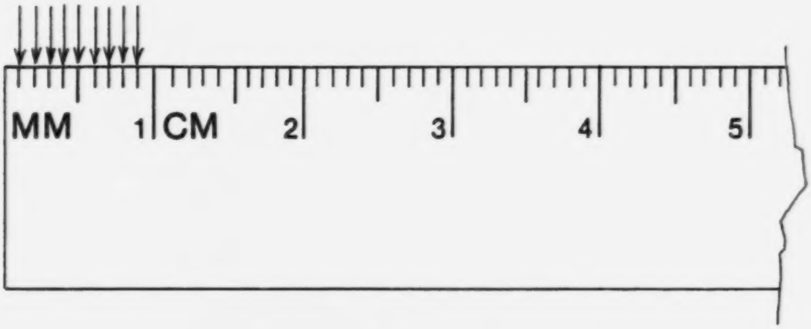
B. Marks on a metric rule

(NOTE: Centimeters is abbreviated cm. and millimeters is abbreviated mm.)

1. Like a fractional-inch rule, metric rule marks are of different heights. They are divided as follows:
2. Meters (a little more than one yard)
3. Decimeters (one-tenth of a meter - not marked on most rules)
4. Centimeters (one-tenth of a decimeter, one-hundredth of a meter)



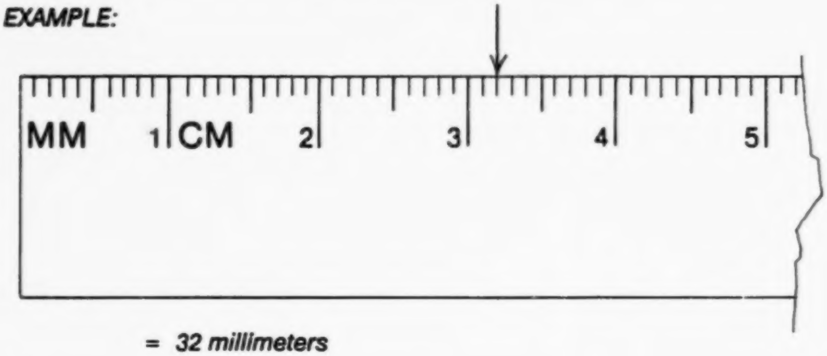
5. Millimeters (one-tenth of a centimeter, one-thousandth of a meter)



6. On a metric rule, the smallest marks are for millimeters. Every five millimeters there will be a taller mark to help in counting millimeters. Every 10 millimeters is a taller mark still, marking centimeters.

7. The centimeter marks are usually numbered. To read the millimeters, multiply the number of centimeters by 10 and then add the millimeters left over

EXAMPLE:



= 32 millimeters

C. Most measurements for auto body dimensions are given in millimeters. Centimeters are occasionally used but decimeters are never used.

D. Adding, subtracting, multiplying and dividing with metric numbers is very easy because everything can easily be converted to millimeters.

1. To convert meters to millimeters, multiply the number of meters by 1,000 (one thousand millimeters per meter).

   Example: 1.6 meters = 1,600 millimeters

2. To convert centimeters to millimeters, multiply the number of centimeters by 10 (10 millimeters per centimeter).

   Example: 18 centimeters = 180 millimeters

3. To add or subtract metric numbers, it is easiest to convert them to millimeters.

   Example: Add 1.3 meters plus 26 centimeters plus 11 millimeters:

   1.3 meters = 1,300 millimeters
   26 centimeters = 260 millimeters
   11 millimeters = 11 millimeters

   Total = 1,571 millimeters

4. A shortcut can be achieved by using decimals:

   a. One meter equals 1.0 meter

   b. One decimeter equals .1 meter

   c. One centimeter equals .01 meter

   d. One millimeter equals .001 meter

Example: 1.3 meters, plus 26 centimeters, plus 11 millimeters:

1.300	*meters*
.260	*centimeters*
.011	*millimeters*

Total = 1.571 meters

1.571 × 1000 = 1,571 millimeters.

5. Converting every metric measure to millimeters always makes multiplication and division easy. It makes it exactly the same as working with whole numbers.

   Example: 520 millimeters divided by 4 = 520/4 = 130 millimeters

   Example: 520 millimeters multiplied by 3 = 520 × 3 = 1560 millimeters

III. **Figuring ratios**

A. Usually, a mixture of refinishing materials will be given as a ratio.

B. Ratios are expressed with the colon (:) sign, such as 3:1:1.

C. 3:1:1 means 3 parts of the first ingredient to 1 part of the second ingredient to 1 part of the third ingredient.

D. Because most ratios deal with liquid measures, it is necessary to use a liquid measuring device and figure how many liquid ounces of mixed material are needed. In some cases it may be possible to work with gallons, half-gallons, quarts and pints.

E. To use liquid ounces remember the following:

1. There are 8 ounces in a half-pint
2. 16 ounces in a pint
3. 32 ounces in a quart
4. 128 ounces in a gallon

F. To mix one-half gallon (two quarts, 64 ounces) of paint when the ratio of paint to reducer to catalyst is 6:1:1, you must determine the ounces needed of each:

1. First, see how many total parts will be in the mixture:

   6+1+1= 8 parts in the mixture

2. Figuring each part as one ounce, how many times will each part have to be added to reach 64 ounces? Simply divide the total number of parts into the number of ounces desired:

   64 ounces + 8 parts = 8

3. Therefore, each part will have to be used 8 times, meaning that the ratio of the ingredients will have to be multiplied by 8 to reach 64 ounces:

   6:1:1 × 8 = 48:8:8

4. Therefore, 48 ounces of paint, 8 ounces of reducer and 8 ounces of catalyst are needed.

G. Many times in mixing ingredients, two ingredients will be mixed according to one ratio and then a third ingredient will be added to the resulting mixture according to another ratio. In such cases, mix the first two first, then figure the total volume of those two ingredients and then use their combined volume in figuring the ratio of the next ingredient.

(Example: Mix ingredient A and ingredient B in a 2:1 proportion. Mix in ingredient C to the resulting mixture of A and B in a 3:1 proportion. It is possible to figure how to mix them at the same time, but the desired chemical reactions might not occur properly.)

IV. Percentages

A. Often a *"percentage of reduction"* will be given for materials rather than a ratio.

B. For example, a certain paint may be mixed properly by reducing it 75% with reducer.

(NOTE: As explained in Module 4 "Paint and Refinishing," enamel paints require reducers and are said to be reduced, while lacquer paints .require thinners and are said to be thinned. They are different chemicals whose effect is to reduce the thickness of the paint so that it can be sprayed through a spray gun.)

C. The percentage equals the amount of the additional ingredient to be added in relation to the total volume of the first ingredient (usually the paint).

1. A 75% reduction means to add reducer equal to 75% of the volume of paint (three-fourths as much reducer as paint, because 75 percent = 3/4).

2. A 100% reduction means to add reducer equal to 100% of the volume of paint (the same amount of reducer as paint).

3. A 150% reduction means to add reducer equal to 150% of the volume of the paint (one and one-half times as much reducer as paint).

D. Once the starting volume of paint, in ounces, is known, it is easy to figure the number of ounces of reducing material that must be added.

Example: To reduce one quart (32 ounces) of enamel paint 50 percent, remember that 50 percent of 32 ounces is 16 ounces (50 percent is one-half). Therefore, add 16 ounces of reducer.

E. In mixing up an exact amount of sprayable paint (including other ingredients) things get more complicated, but this is often necessary to avoid waste. (Some special modern paints cost as much as $75 per quart, so waste becomes an issue.)

F. To mix up exactly one quart (32 ounces) of sprayable paint that will be reduced 50 percent, start with the right amount of paint and add the right amount of reducer to get 32 ounces.

a. To do this, it is easiest to convert the percentage to a ratio.

Example: A 50 percent reduction means that there will be half as much reducer as paint, meaning it will require twice as much paint as reducer. Therefore the ratio is 2:1. A ratio of 2:1 means three parts will be used (2+1). Divide the total number of parts to be used into the amount of material desired. Three parts divided into 32 ounces = 32/3 = 10.7. Therefore, 10.7 ounces of reducer and twice as much paint will be used (10.7 × 2 = 21.4). 21.4 plus 10.7 = 32.1 ounces. The .1 is all that will be wasted, assuming that exactly 32 ounces of paint are needed.

G. Figuring percentage reductions is fairly simple because the reductions usually fall into a limited number of percentages which can be reduced to ratios. The ratio can be thought of as the answer to the question: How many times do I have to multiply the percentage to equal 100%?

Examples:

20 percent equals 5:1 (5 × 20% = 100%)
33 1/3 percent equals 3:1 (3 × 33.3% = 100%)
50 percent equals 2:1 (2 × 50% = 100%)
100 percent equals 1:1 (1 × 100% = 100%)

H. Some other common percentages are best expressed as ratios in terms of fourths:

1. 75 percent equals 4:3 (75% × 4/3 = 100%)

   (75% is 3/4, so there will be 3 parts of reducer to four parts of paint)

2. 125 percent equals 4:5 (125% × 4/5 = 100%)

   (125% is 5/4, so there will be 5 parts of reducer to 4 parts of paint)

3. 150 percent equals 2:3 (150% × 2/3 = 100%)

   (150% is 6/4, which equals 3/2. There will be 3 parts of reducer to two parts of paint.)

HANDOUT #1, LESSON ONE

TAKING THE MEASURE OF THINGS IN THE AUTO BODY PROFESSION

Measuring skills are vital to the body shop repairman because they are encountered in many situations. If damage is not measured correctly you will have to redo the job and you will not make a profit. If you figure repair costs incorrectly you may lose money (or a customer). If paint or other repair materials are not mixed correctly you will have to redo the job and you will not make a profit. There are three main areas calling for measuring skills:

- Measuring damage
- Figuring repair costs
- Mixing repair materials

Being able to figure correctly in these situations will save many headaches. The skills needed are simple arithmetic:

- Addition and subtraction
- Division and multiplication
- Working with ratios and percentages

MEASURING DAMAGE

The wide use of metric measurements in the automotive field means the student must know how to work with the metric system, especially in measuring length, width and height dimensions of vehicles. When modern unibody vehicles are seriously damaged, precise measurements must be taken to determine the extent of the damage and process of the repair.

In many cases, such measurements will be taken in millimeters. For this reason, the use of a metric rule and the ability to add and subtract measurements, in both metric and fractional inch scales, is important.

FIGURING REPAIR COSTS

The many parts that can be damaged in a collision require the ability to figure the estimated costs of collision repair accurately. In addition to figuring repairs, the large quantity of supplies ordered by body shops means that the body shop person must be able to check the figures on invoices and take advantage of such things as volume discounts.

FIGURING RATIOS

Many refinishing materials are composed of parts that must be mixed together. The directions for mixing are often given in ratios. Because the amount of material for each repair will vary, a technician must be able to mix up any volume of material to avoid waste.

FIGURING PERCENTAGES

In mixing paint for refinishing, percentages are used in many cases. For example, a certain paint must be thinned 33 1/3% with thinner. The body shop technician must know how to apply the percentage to the amount of material to be mixed.

In ordering parts, supplies, or equipment, discounts may be offered and it is necessary to figure the savings to determine how economical a discounted or sale-priced item is.

DICTIONARY OF TERMS AND DEFINITIONS FOR AUTO BODY MEASUREMENT

1. Decimal – A number expressed with a decimal point. It equals a fraction with an unwritten denominator that is a multiple of 10. *Examples: .1 = 1/10, .01 = 1/100, .125-125/1000.*

2. Fraction – Any number that expresses a number other than a whole number by means of showing a numerator over a denominator.

3. Fractional-inch rule – A rule using yards, feet, inches and fractions of inches as units of measurement.

4. Metric rule – A rule using meters, decimeters, centimeters, and millimeters as units of measurement.

5. Percentage – A means of expressing part of a whole as a whole number instead of a fraction. Done by dividing the whole into 100 parts. By doing so we can express 3/4, for example, as 75 percent (75/100), 1/2 as 50 percent (50/100), etc.

6. Ratio – The relative size of two quantities expressed as a relationship between numbers representing their relative sizes. A colon (:) between two numbers indicates a ratio.

   Examples: 4:3, 8:5:1.

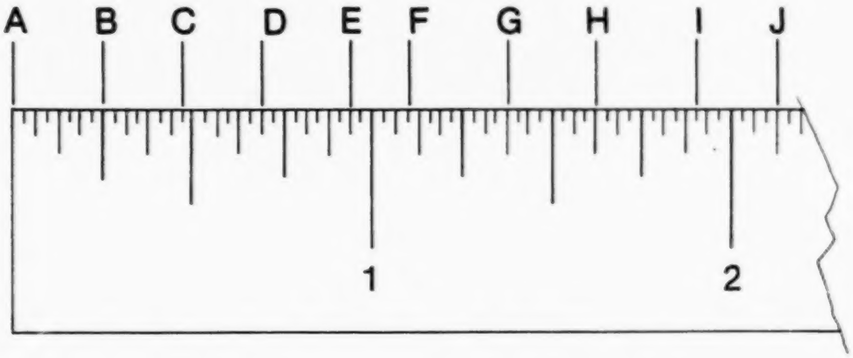
7. Whole number -- Any number that is expressed without using a fraction or a decimal.

ASSIGNMENT SHEET #1, LESSON ONE

WORKING WITH THE FRACTIONAL INCH RULE

PART I—READING THE FRACTIONAL-INCH RULE

I. Using the rule below, fill in the correct answer to questions 1-12, (in lowest common demoninator)



1. The distance from A to B is ______ inches.
2. The distance from A to C is ______ inches.
3. The distance from A to D is ______ inches.
4. The distance from A to E is ______ inches.
5. The distance from A to F is ______ inches.
6. The distance from A to G is ______ inches.
7. The distance from A to H is ______ inches.
8. The distance from A to I is ______ inches.
9. The distance from A to J is ______ inches.
10. The distance from B to D is ______ inches.
11. The distance from D to F is ______ inches.
12. The distance from G to J is ______ inches.

PART II–ADDING, SUBTRACTING, AND DIVIDING MEASUREMENTS

I. Fill in the blank with the correct answer to the question (in lowest common denominator).

1. The frame rail on a damaged Ford Escort measures 37 3/8 inches. It should measure 40 1/16 inches. How much shorter is the frame rail than it should be? ________.

2. The distance from the centerline to the left inner rocker panel on a Pontiac Fiero is 33 1/2 inches and the distance from the centerline to the right inner rocker panel is 32 5/32 inches. What is the total distance between the two inner rocker panels? ________.

3. In drilling holes for an emblem on a new fender the rearmost hole is to be 2 7/32 inches from the rear edge of the fender. If the front hole for the emblem is 1 3/4 inches forward of the rear whole, how far is the front hole from the rear edge of the fender? ________.

4. In lining up a hood you discover that the gap on the left side is 5/16 of an inch and the gap on the right side is 1/8 of an inch. Which way, right or left, will the hood have to be adjusted to make the gaps equal? ________. What should the gaps be in order to be equal? ________. How much will the hood have to be moved in the proper direction to make the gaps equal? ________.

5. You are measuring a door opening diagonally to determine how much the door hinge pillar must be pulled forward to bring the door opening back to specifications. You discover that the diagonal measure of the damaged opening is 43 1/16 inches and it should be 45 9/32. How far will the hinge pillar have to be pushed out to bring it back into proper alignment? *(NOTE: Assume you are making the push diagonally, the same as the measurements were taken.)* ________.

6. You are going to section a windshield pillar and after consulting the service manual, you determine you should cut the pillar exactly in half. If the total length of the pillar is 1 foot, 7 and 3/4 inches, how far down from the top of the pillar will you make your cut? ________.

7. You need to replace weld-on studs for a door side molding and the old door is so seriously damaged that you cannot tell how far apart the weld-on studs are supposed to be. The instructions for the molding say only that there should be five studs, one at each edge of the door and the other three spaced such that the distance between each of the five is the same. If the door is 32 1/2 inches long, where will you locate each of the middle studs, measured from the front of the door? ________.

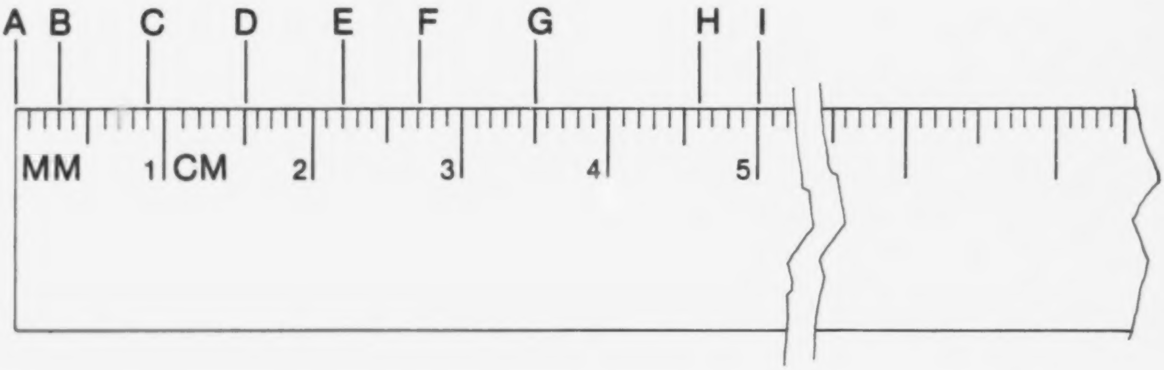
8. You wish to make a plug weld which will weld three panels together, but aren't sure this can be properly accomplished. You consult the service manual for the vehicle and also a welding manual. Both say it can be done provided the thickness of the three panels together is not more than 9/32 of an inch. One panel is 1/16 inch thick, another is 3/32 inch thick and the third is 1/8 inch thick. Will you be able to make the weld? ________.

ASSIGNMENT SHEET #2, LESSON ONE

WORKING WITH THE METRIC RULE

PART I–READING THE METRIC RULE

I. Using the rule below, fill in the correct answer to questions 1-12.



1. The distance from A to B is ______ millimeters.
2. The distance from A to C is ______ millimeters.
3. The distance from A to D is ______ millimeters.
4. The distance from A to E is ______ millimeters.
5. The distance from A to F is ______ millimeters.
6. The distance from A to G is ______ millimeters.
7. The distance from A to H is ______ millimeters.
8. The distance from B to C is ______ millimeters.
9. The distance from B to D is ______ millimeters.
10. The distance from C to F is ______ millimeters.
11. The distance from D to F is ______ millimeters.
12. The distance from B to I is ______ millimeters.

PART II—ADD AND SUBTRACT METRIC MEASUREMENTS

I. Fill in the blank with the correct answer to the question.

1. The frame rail on a damaged Renault Alliance measures 1241 millimeters. It should measure 1256 millimeters. How much shorter is the frame rail than it should be? ______________.

2. The distance from the centerline to the left inner rocker panel on a Corvette is 515 millimeters and the distance from the centerline to the right inner rocker panel is 511 millimeters. What is the total distance between the two inner rocker panels? ______________.

3. In drilling holes for an emblem on a new fender the rearmost hole is to be 47 millimeters from rear edge of the fender. If the front hole for the emblem is 33 millimeters forward of the rear hole, how far is the front hole from the rear edge of the fender? ______________.

4. In lining up a hood you discover that the gap on the left side is 7 millimeters and the gap on the right side is 11 millimeters. Which way, right or left, will the hood have to be adjusted to make the gaps equal? ______________. What should the gaps be in order to be equal? ______________. How much will the hood have to be moved in the proper direction to make the gaps equal? ______________.

5. You are measuring a door opening diagonally to determine how much the door hinge pillar must be pulled forward to bring the door opening back to specifications. You discover that the diagonal measure of the damaged opening is 1121 millimeters and it should be 1156 millimeters. How far will the hinge pillar have to be pulled to bring it back into proper alignment? ______________.

6. You are going to section a windshield pillar and after consulting the service manual you determine you should cut the pillar exactly in half. If the total length of the pillar it 374 millimeters, how far down from the top of the pillar will you make your cut? ______________.

7. You need to replace weld-on studs for an door side molding and the old door is so seriously damaged that you cannot tell how far apart the weld-on studs are supposed to be. The instructions for the molding say only that there should be five studs, one at each edge of the door and the other three spaced such that the distance between each of the five is the same. If the door is 1140 millimeters long, where will you locate each of the middle studs, measured from the front of the door? ______________, ______________, ______________.

ASSIGNMENT SHEET #3, LESSON ONE

WORKING WITH RATIOS AND PERCENTAGES

I. Fill in the blank with the correct answer to the question.

1. You are going to mix some acrylic urethane clear. It calls for a ratio of 16:1 of paint to a special additive. If you are going to mix one gallon of paint with the additive, how much additive will you use? _______.

2. You have determined you will need some retarder in some acrylic lacquer paint you wish to use. You mix a very small quantity and spray it and determine that it is the correct mixture. In mixing up the small quantity you used one pint of paint, which you then thinned 125% with thinner, and then you added one ounce of retarder. What is the ratio of paint to thinner to retarder? (NOTE: To be expressed as Paint:Thinner:Retarder.) _______. After determining the ratio you now want to take one-half gallon of the paint and mix it with the thinner and the retarder. How much thinner will you use? _______. How much retarder will you add? _______.

3. You are going to mix up an enamel primer calling for a ratio of 3-1 for the primer to reducer. If you are going to use one quart of primer, how much reducer will you use? _______.

4. You are going to mix an epoxy primer with a two-step mixing procedure. In the first step, the primer and the activator are mixed in the ratio of 2:1. Then the resulting mixture is mixed in the ratio of 4:1 with reducer. If you are going to start with two quarts of the epoxy primer, how much activator will you add? _______. How much reducer will you then add to the resulting mixture? _______. How much sprayable material will you end up with? _______.

5. You have encountered a problem spray situation in which you will be spraying some urethane enamel which has a ratio of 8:1 for paint to activator. You then decide you need to add some accelerator to speed the drying time. The accelerator is added to the paint and activator mixture in the ratio of 6:1. After an initial spray attempt, you realize you are also going to need some fisheye eliminator in the ratio of 8:1 to the previous mixture. If you started with one gallon of paint, how much activator did you add? _______. How much accelerator? _______. How much fisheye eliminator? _______. How much sprayable mixture do you have after you've mixed everything? _______.

6. A base coat calls for a mixing ratio of 8:1:16 for base color to activator to basemaker. If you have one gallon of basemaker and decide you need to mix it all up, how much base color will you add? _______. How much activator? _______. What will be the total amount of paint? _______.

7. You are going to mix some acrylic urethane paint. It calls for a 20 percent reduction of the paint with a special additive. If you are going to mix one gallon of paint with the additive, how much additive will you use? _______.

8. You are going to mix up an enamel primer calling for a 33 1/3 percent reduction with reducer. You want to mix it up so that you have exactly one gallon of sprayable material. How much paint do you start with? _______. How much reducer do you add to it? _______.

9. You have determined you will need some retarder in some acrylic lacquer paint you wish to use. You mix a very small quantity and spray it and determine that it is the correct mixture. In mixing up the small quantity you used one pint of paint, which you then thinned with 24 ounces of thinner, and then you added 4 ounces of retarder to that mixture. What is the percent reduction with the thinner? ________. What is the percent reduction of the paint-and-thinner mixture with retarder? ________. If you were going to express this as a ratio of paint:thinner:retarder, what would the ratio be? ________.

10. You are going to mix an epoxy primer with a two-step mixing procedure. In the first step, the primer and the activator are mixed in the ratio of 2:1. Then the resulting mixture is then reduced 50% with reducer. If you are going to start with two quarts of the epoxy primer, how much reducer will you then add to the primer and activator mixture? ________. How much sprayable material will you end up with? ________.

11. You have been told to keep track of the materials on hand and to order materials anytime they reach 20 percent of a full order. If a full order of sanding disks is a case of 50, then how many disks from a full order do you have to use up before it's time to order again? ________.

12. Your boss has told you that you will be getting a 7.5 percent raise. If you are currently making $1,000.00 per month, how much more money will you make each month? ________.

13. The insurance company has told you that they will not pay any more than your original estimate on a job plus 5 percent. If your original estimate was $2,000 for a job and that job ended up costing $2,167, what portion of the bill will the insurance company not pay? ________.

14. You are ordering parts and find out that you are short of the amount of parts and supplies needed for the month to receive a 10 percent discount from your supplier. You have ordered $13,950 worth of parts and supplies and need an order of $15,000 to get the discount. You have been wanting to buy a new $1,550 attachment to your frame equipment from the same supplier. If you take the time to order the $1,550 attachment, how much more will you pay to the supplier than you would have if you hadn't ordered the attachment? ________. In effect, how much did you pay for the attachment by taking advantage of the 10 percent discount? ________.

15. Each of your suppliers adds 3 percent onto their bill if it is not paid by the 15th of the month. If you have five suppliers and your average monthly balance with each of them is $6,000, how much would you lose in a year's time by not paying any of your bills before the 15th? ________.

16. A vehicle is being worked on in the shop with a checklist of 100 tasks to be performed on it. With each of you working three full class periods, Judy does 21 of them, Ed does 9, the instructor does 26, and you do 17. What percentage of the work on the vehicle has been completed? ________. If there is only one more full class period left before the car must be completed, and if all four of you work on it during the period, does it look like you will get the car done on time? (Assume that each of the 100 tasks takes the same amount of time). ________.

ANSWERS TO ASSIGNMENT SHEETS

ASSIGNMENT SHEET #1

PART I

1. 1/4
2. 15/32
3. 11/16
4. 15/16
5. 1 - 3/32
6. 1 - 3/8
7. 1 - 5/8
8. 1 - 29/32
9. 2 - 1/8
10. 7/16
11. 13/32
12. 3/4

PART II

1. 2 11/16
2. 65 21/32
3. 3 31/32
4. Left, 7/32, 3/32
5. 2 7/32
6. 9 7/8
7. 8 1/8, 16 1/4, 24 3/8
8. Yes

ASSIGNMENT SHEET #2

PART I

1. 3
2. 9
3. 15
4. 22
5. 27
6. 35
7. 46
8. 6
9. 12
10. 18
11. 12
12. 47

PART II

1. 2 - 11/16
2. 65 - 21/32
3. 3 - 31/32
4. Left, 7/32, 3/32
5. 2 - 7/32
6. 9 - 7/8
7. 8 - 1/8, 16 - 1/4, 24 - 3/8
8. Yes

ASSIGNMENT SHEET # 3

1. 8 ounces
2. 16:20:1, 80 oz., 4 oz.
3. 10.7 ounces
4. one quart (32 oz.), 24 oz., 120 oz.
5. 16 oz, 24 oz., 21 oz, 189 oz.
6. 64 oz., 8 oz., 200 oz.
7. 25.6 oz.
8. 96 oz., 32 oz.
9. 150%, 10%, 4:6:1
10. 48 oz., 144 oz.
11. 40
12. $75.00
13. $67.00
14. $0.00, Nothing
15. $10,800
16. 73%, No

MODULE: INTRODUCTION TO AUTO BODY

UNIT II: MEASURING

UNIT II TEST

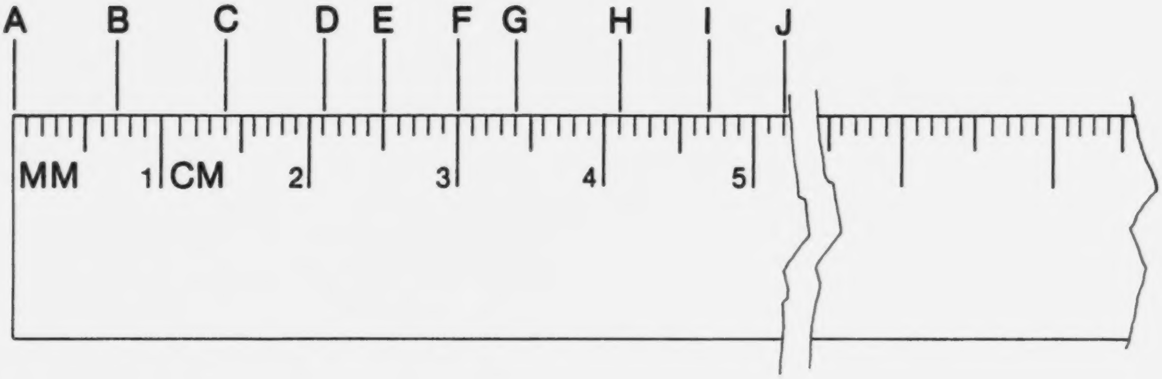
PART I—READ A RULE

I. Using the rule below, fill in the correct answer to questions 1-10 by selecting the correct letter(s) of the answer from below. (Some may be used more than once.)

A. 4
B. 7
C. 9
D. 11
E. 14

AB. 21
AC. 25
AD. 26
AE. 27
BC. 30

BD. 34
BE. 37
CD. 41
CE. 48
DE. 52



_____1. What is the distance from A to B in millimeters?

_____2. What is the distance from A to C in millimeters?

_____3. What is the distance from A to D in millimeters?

_____4. What is the distance from A to E in millimeters?

_____5. What is the distance from A to F in millimeters?

_____6. What is the distance from A to G in millimeters?

_____7. What is the distance from A to H in millimeters?

_____8. What is the distance from B to D in millimeters?

_____9. What is the distance from C to D in millimeters?

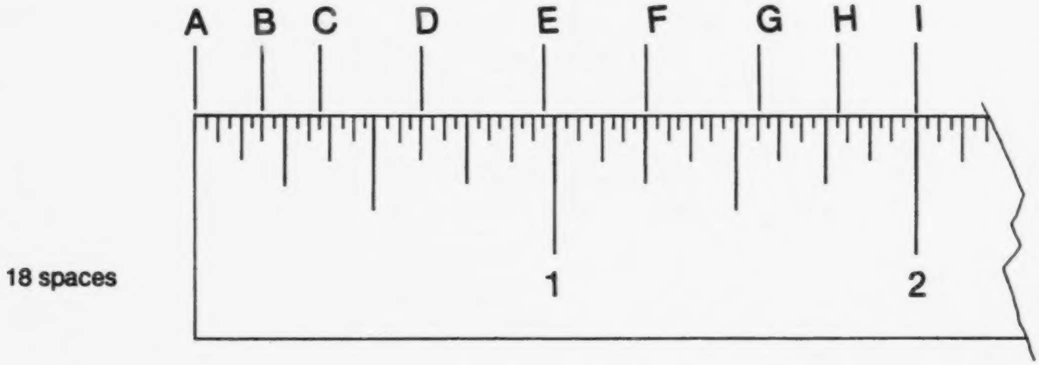
_____10. What is the distance from D to F in millimeters?

II. Using the rule below, fill in the correct answer to questions 11-20 by selecting the correct letter(s) of the answer from below. (Some may be used more than once.)

A. 3/16
B. 9/32
C. 5/16
D. 11/32
E. 7/16

AB. 19/32
AC. 5/8
AD. 31/32
AE. 1 - 1/8
BC. 1 - 1/4

BD. 1 - 9/16
BE. 1 - 5/8
CD. 1 - 25/32
CE. 1 - 3/4
DE. 1 - 31/32



_____11. What is the distance from A to B in inches?

_____12. What is the distance from A to C in inches?

_____13. What is the distance from A to D in inches?

_____14. What is the distance from A to E in inches?

_____15. What is the distance from A to F in inches?

_____16. What is the distance from A to G in inches?

_____17. What is the distance from A to H in inches?

_____18. What is the distance from B to D in inches?

_____19. What is the distance from C to D in inches?

_____20. What is the distance from D to F in inches?

(NOTE: Completion of this portion of the unit test is the evalution for Competency B1, "Read a rule, fractional inch and metric." Of the 20 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, ____ correct or below = student should retake this portion of the unit test.)

PART II–SOLVE PROBLEMS INVOLVING VOLUMES

I. Select the correct answer from the five choices listed.

_____21. You are going to mix some acrylic urethane clear. It calls for a ratio of 8:1 of paint to a special additive. If you are going to mix one gallon of paint with the additive, how much additive will you use? (a) 8 ounces, (b) 16 ounces, (c) 24 ounces, (d) 32 ounces, (e) 40 ounces.

_____22. You have determined you will need some retarder in some acrylic lacquer paint you wish to use. You mix a very small quantity and spray it and determine that it is the correct mixture. In mixing up the small quantity you used one pint of paint, which you then thinned 150% with thinner, and then you added two ounces of retarder. What is the ratio of paint to thinner to retarder? *(NOTE: To be expressed as Paint:Thinner:Retarder.)* (a) 8:12:1, (b) 4:6:1, (c) 2:3:1, (d) 6:4:1, (e) 12:8:1.

_____23. After determining the ratio in question number 17 you now want to take one-half gallon of the paint and mix it with the thinner and the retarder. How much thinner and retarder will you use? (a) 64 ounces thinner, 8 ounces retarder, (b) 64 ounces thinner, 16 ounces retarder, (c) 96 ounces of thinner, 8 ounces retarder, (d) 96 ounces of thinner, 16 ounces retarder, (e) 128 ounces of thinner, 16 ounces retarder.

_____24. You are going to mix up an enamel primer calling for a ratio of 5:1 for the primer to reducer. If you are going to use one-half gallon of primer, how much reducer will you use? (a) 6.4 ounces, (b) 9.6 ounces, (c) 12.8 ounces, (d) 16 ounces, (e) 25.6 ounces.

_____25. You are going to mix an epoxy primer with a two-step mixing procedure. In the first step, the primer and the activator are mixed in the ratio of 3:1. Then the resulting mixture is mixed in the ratio of 4:1 with reducer. If you are going to start with three quarts of the epoxy primer, how much activator will you add? How much reducer will you then add to the resulting mixture? (a) 16 ounces activator, 16 ounces reducer, (b) 16 ounces activator, 32 ounces reducer, (c) 32 ounces activator, 16 ounces reducer, (d) 32 ounces activator, 32 ounces reducer, (e) 64 ounces activator, 32 ounces reducer.

_____26. You have encountered a problem spray situation in which you will be spraying some urethane enamel which has a ratio of 8:1 for paint to activator (A). You then decide you need to add some accelerator (B) to speed the drying time. The accelerator is added to the paint and activator mixture in the ratio of 6:1. After an initial spray attempt, you realize you are also going to need some fisheye eliminator (C) in the ratio of 6:1 to the previous mixture. If you started with two quarts of paint, how much activator, accelerator and eliminator did you add? (a) 4 ounces A, 6 ounces B, 7 ounces C, (b) 8 ounces A, 12 ounces B, 14 ounces C, (c) 8 ounces A, 16 ounces B, 16 ounces C, (d) 12 ounces A, 18 ounces B, 24 ounces C, (e) 12 ounces A, 24 ounces B, 24 ounces C.

_____27. A base coat calls for a mixing ratio of 4:1:8 for base color to activator to basemaker. If you have one-half gallon of *basemaker* and decide you need to mix it all up, how much base color and how much activator will you mix? (a) 32 ounces base color, 8 ounces activator, (b) 32 ounces base color, 16 ounces activator, (c) 64 ounces base color, 16 ounces activator, (d) 64 ounces base color, 32 ounces activator, (e) 64 ounces base color, 64 ounces activator.

II. Select the correct answer from the five choices listed.

_____28. You are going to mix some acrylic urethane paint. It calls for a 20 percent reduction of the paint with a special additive. If you are going to mix one quart of paint for a spot repair, how much additive will you use? (a) 3.2 ounces, (b) 6.4 ounces, (c) 9.6 ounces, (d) 12.8 ounces, (e) 16 ounces.

_____29. You have determined you will need some retarder in some acrylic lacquer paint you wish to use. You mix a very small quantity and spray it and determine that it is the correct mixture. In mixing up the small quantity you used one pint of paint, which you then thinned with 24 ounces of thinner, and then you added 4 ounces of retarder to that mixture. What is the percent reduction with the thinner? (a) 50 percent, (b) 100 percent, (c) 125 percent, (d) 150 percent, (e) 200 percent.

_____30. In question 24, above, what is the percent reduction of the paint-and-thinner mixture with retarder? (a) 5 percent, (b) 10 percent, (c) 20 percent, (d) 50 percent, (e) 75 percent.

_____31. You are going to mix up an enamel primer calling for a 33 1/3 percent reduction with reducer. You want to mix it up so that you have exactly one-half gallon of sprayable material. How much paint do you start with and how much reducer do you add to it? (a) 32 ounces paint, 16 ounces reducer, (b) 48 ounces paint, 16 ounces reducer, (c) 48 ounces paint, 32 ounces reducer, (d) 64 ounces paint, 16 ounces reducer, (e) 64 ounces paint, 32 ounces reducer.

_____32. In the question above, if you were going to mix up one gallon of material instead of one-half gallon, by what percentage would you reduce it? (a) 20 percent, (b) 33 1/3 percent, (c) 66 2/3 percent, (d) 100 percent, (e) You would have to read the directions to find out.

_____33. You are going to mix an epoxy primer with a two-step mixing procedure. In the first step, the primer and the activator are mixed in the ratio of 2:1. Then the resulting mixture is then reduced 50 percent with reducer. If you are going to start with one quart of the epoxy primer, how much reducer will you then add to the primer and activator mixture. (a) 12 ounces, (b) 16 ounces, (c) 24 ounces, (d) 32 ounces, (e) 48 ounces.

_____34. In problem 28, above, how much sprayable material will you end up with? (a) 48 ounces, (b) 64 ounces, (c) 72 ounces, (d) 84 ounces, (e) 90 ounces.

_____35. You have to mix up some polychromatic acrylic urethane paint, which calls for a reduction of 25 percent with reducer. After making the reduction you determine you will need to add hardener at a ratio of 5:1. If you want to end up with three quarts of sprayable paint after you have added all the ingredients, how much paint will you start with? (a) 32 ounces, (b) 48 ounces, (c) 64 ounces, (d) 80 ounces, (e) 96 ounces.

(NOTE: Completion of this portion of the unit test is the evaluation for Competency B2, "Solve problems involving volume and ratios." Of the 15 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below= student should retake this portion of the unit test.)

ANSWERS TO UNIT II TEST

PART I.

1. B
2. E
3. AB
4. AC
5. BC
6. BD
7. CD
8. E
9. B
10. C

11. A
12. D
13. AC
14. AD
15. BC
16. BD
17. CD
18. E
19. B
20. AC

PART II.

21. B
22. A
23. C
24. C
25. D
26. B
27. A

28. B
29. D
30. B
31. B
32. B
33. C
34. C
35. C

MODULE: INTRODUCTION TO AUTO BODY

UNIT III: HAND TOOLS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify hand tools used in auto body repair and know the proper use of the tools. Mastery will be evidenced by scoring _____ percent on the unit test and by demonstrating safe practices whenever using hand tools.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit the student should be able to:

Lesson 1:

I. Demonstrate the safe use and maintenance of hammers (Competency C1, Part I of Unit III test)

II. Demonstrate the safe use and maintenance of screwdrivers (Competency C1, Part II of Unit III test)

III. Demonstrate the safe use and maintenance of common wrenches (Competency C1, Part III of Unit III test)

IV. Demonstrate the safe use and maintenance of types of socket wrenches (Competency C1, Part III of Unit III test)

V. Demonstrate the safe use and maintenance of types of pliers and cutters (Competency C1, Part IV of Unit III test)

VI. Demonstrate the safe use and maintenance of types of miscellaneous hand tools (Competency C1, Part V of Unit III test)

Lesson 2:

I. Demonstrate principles of using auto body hand tools correctly and safely (Competency C2, Part VII of Unit III test)

II. Demonstrate the safe use and maintenance of body hammers (Competency C2, Part VII of Unit III test)

III. Demonstrate the safe use and maintenance of miscellaneous auto body hand tools (Competency C2, Part VII of Unit III test)

MODULE: INTRODUCTION TO AUTO BODY

UNIT III: HAND TOOLS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

  1. Lesson 1: General hand tools

    a. Information outline

  2. Lesson 2: Auto body hand tools

    a. Information outline

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. This unit should be self-explanatory. Lesson 1 is a good opportunity to have students study the material on their own and take the test. The instructor might only lecture over the high points, such as the difference between body hammers and common hammers.

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2. Czapskie, George S., et. al. *Auto Body Repair.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1977.

3. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL. 1984.

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5. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

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MODULE: INTRODUCTION TO AUTO BODY

UNIT III: HAND TOOLS

LESSON ONE: GENERAL HAND TOOLS

(NOTE: The body shop technician will be expected to acquire a complete set of hand tools and know the use of each. The technician will start with a basic set and add to it as new tools are needed. The journeyman technician will have a complete set of tools in a large tool chest. Hand tools are divided into two types in this discussion: those with widespread use in many fields {common hand tools}, and those specific to auto body work.)

I. Hand tools

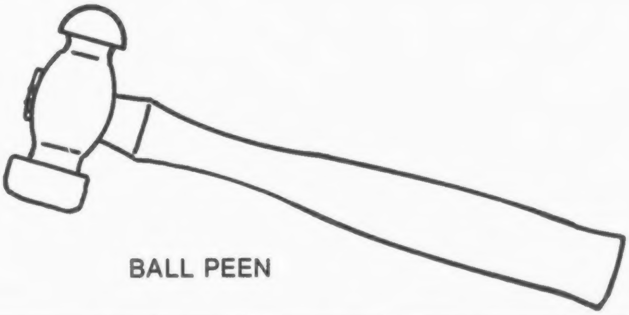
A. Common hammers

1. Come in a variety of shapes and sizes
2. The size of the hammer is determined by the weight of the head.
3. Hammers are used to help straighten and align damaged metal.
4. Maintenance
    a. Hammers should be kept free of dirt and grease, with the faces smooth and free of all foreign matter.
    b. Hammers should be stored in a dry place to prevent rust.
5. Safety
    a. Always be sure the head is secured firmly on the handle
    b. Be sure the handle is in good condition
    c. Strike flat-surfaced hammers flat against the object being struck, never at an angle

B. Types of common hammers

1. Ball peen (FIG. 1-1)

FIGURE 1-1



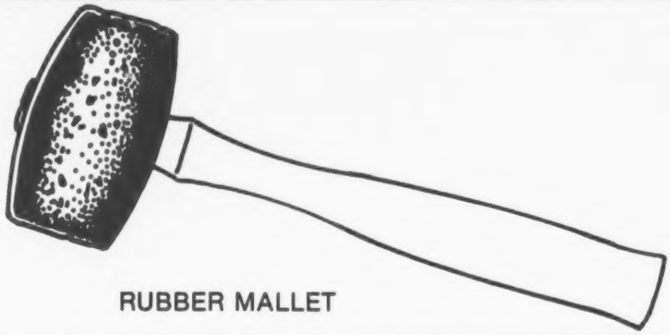
BALL PEEN

   a. Dome head on one side, flat head on other side

   b. Used to rough out metal and drive punches and chisels

2. Rubber mallet (FIG. 1-2)

FIGURE 1-2



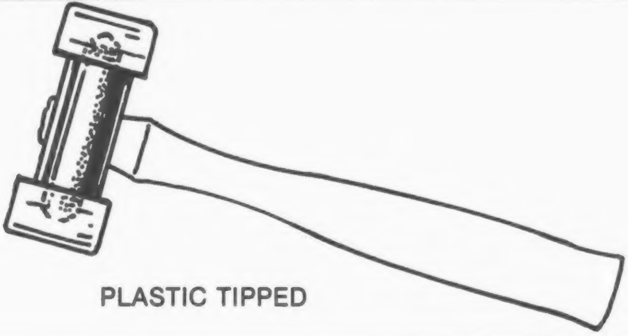
RUBBER MALLET

   a. Molded hard rubber head with two large faces

   b. Used to rough out metal which could be damaged by a steel hammer, or which requires a larger striking surface

3. Plastic tip hammer (FIG. 1-3)

FIGURE 1-3



PLASTIC TIPPED

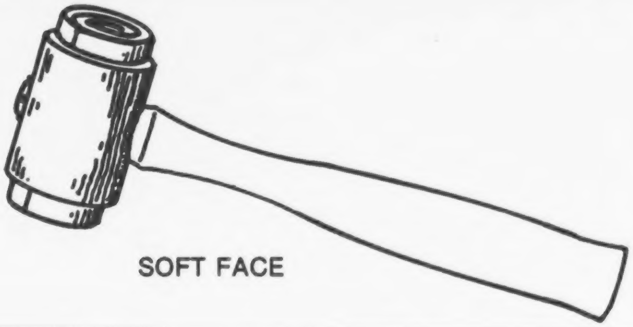
   a. Steel head with plastic covering on faces

   b. Used to strike surfaces which could be damaged by using a steel hammer

   c. Often used on mechanical parts

4. Soft-face hammer (FIG. 1-4)

FIGURE 1-4

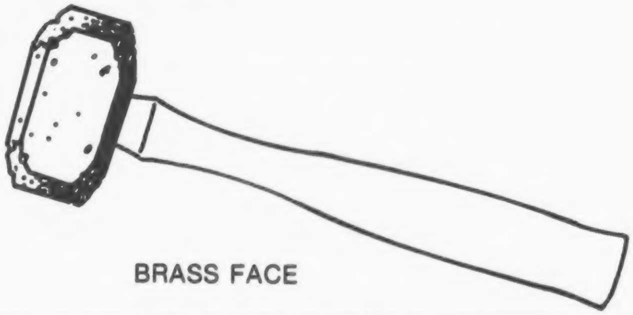


   a. Leather face covering steel heads

   b. Used on surfaces which are especially vulnerable to damage, such as chrome trim

5. Brass-face hammer (FIG. 1-5)

FIGURE 1-5



   a. Steel hammer with soft brass covering faces

   b. Used on mechanical parts which cannot be marred, such as suspension parts

II. Screwdrivers

A. Used to tighten and remove different types of screws

B. Come in many sizes and designs

C. The size is the length of the shank (blade).

D. Maintenance

   1. Should be kept free of dirt and grease

2. Heads should be kept in good condition, free from nicks.
3. Should be stored in a dry place to prevent rust

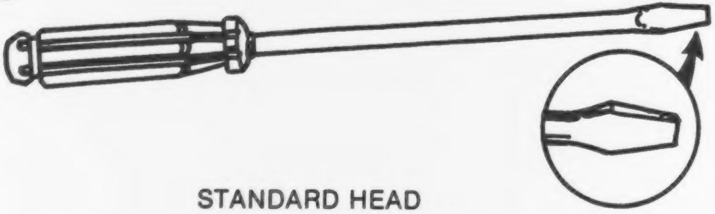
E. Safety

1. The right size screwdriver should be used for each job.
    a. The screwdriver should be of the right length for access to leverage.
    b. The head of the screwdriver should match the head of the screw, both in the type of screw and the size of the screw.
    c. Never try to use another tool, such as an locking pliers, to grab the handle of the screwdriver and get more leverage. If you can't turn it with your hand, then another tool is needed.
    d. Use screwdrivers with insulated handles to prevent electric shock
    e. Do not use a screwdriver as a punch or chisel

F. Types of screwdrivers

1. Standard tip (FIG. 1-6)

FIGURE 1-6

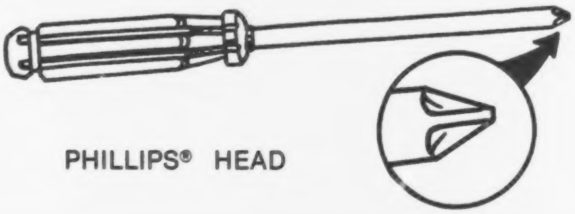


STANDARD HEAD

    a. Fits standard slotted screws
    b. May have either a square shank or a round shank

2. Phillips® (FIG. 1-7)

FIGURE 1-7



PHILLIPS® HEAD

   a. Used on Phillips® head screw

   b. Has four "teeth" that fit into the recesses of the screw

3. Reed and Prince

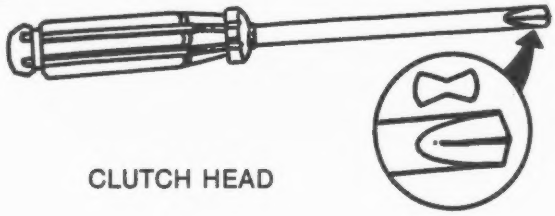
   a. Similar to Phillips®

   b. Has sharper point than Phillips®

   c. Should not be used interchangeably with Phillips®

4. Clutch head (FIG. 1-8)

FIGURE 1-8



CLUTCH HEAD

   a. Used on clutch-head screws

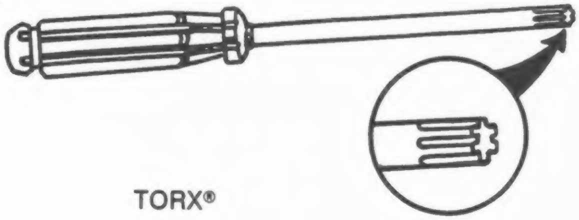
   b. Has hour glass shaped head

5. Torx® head (FIG. 1-9)

   a. Has a six-pointed head

   b. Used on Torx® head screws, which are used on some trim fasteners

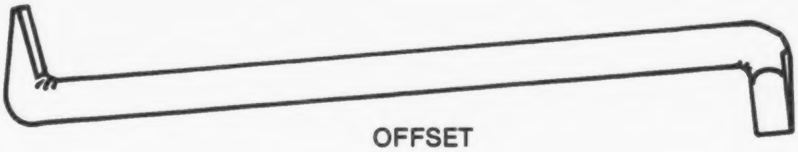
FIGURE 1-9



TORX®

6. Offset (FIG. 1-10)

FIGURE 1-10



a. May have any type of head

b. Used in areas where a standard screwdriver will not fit

III. **Common wrenches**

A. Wrenches come in a wide variety of designs and are used to loosen bolts or machine screws.

B. The size of the wrench is the size of bolt head it will fit. The larger the size, the longer the wrench.

C. Maintenance

1. Wrenches should be kept free of dirt and grease.

2. Wrenches should be stored in a dry place to prevent rust.

3. Wrenches with distorted jaws should be discarded.

D. Safety

1. Always use the proper size wrench

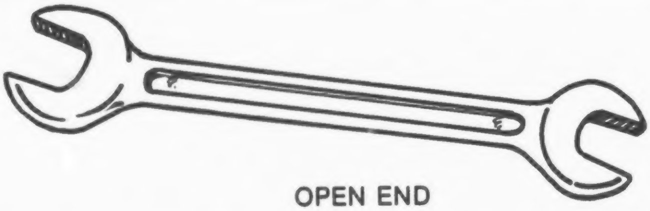
2. Never use metric wrenches on USCS (fractional-inch) bolts or vice-versa

3. Never use a wrench as a hammer or pry bar

E. Types of common wrenches

1. Open end (FIG. 1-11)

FIGURE 1-11



a. The bolt is griped on only two sides.

b. Open end allows easier access to bolt in many situations

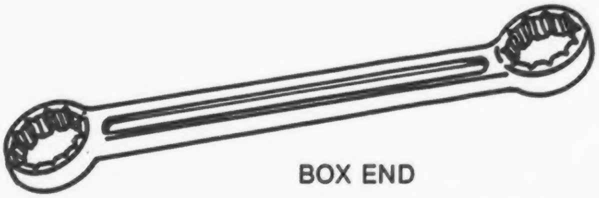
c. Allows more chance of damaging six-sided (hex) bolts because it provides grip on only two sides of bolt

d. Will be the wrench of choice for almost all square-head bolts

e. Has a different size opening on each end, with the two sizes differing by either 1/8 inch, 1/16 inch or 1/32 inch, for sizes up to one inch

2. Box end (FIG. 1-12)

FIGURE 1-12



BOX END

a. The bolt is gripped on all edges.

b. May have either 6- or 12-point heads

(NOTE: The points are the number of openings into which the nut or bolt may go. There is also an 8-point head, but it is not often used as it can only work on square nuts.)

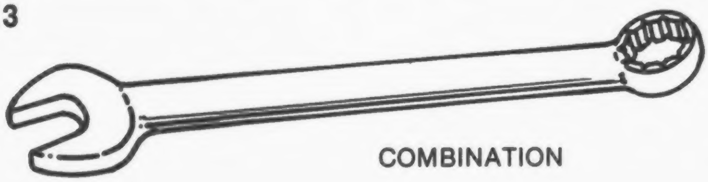
c. Allows less chance of damaging bolt head

d. Box end wrenches are safer than open-end wrenches because they grip hex nuts more firmly, allowing less chance for the wrench to slip.

e. Box end wrenches have a different size opening at each end, differing by 1/8 inch, 1/16 inch or 1/32 inch.

3. Combination (FIG. 1-13)

FIGURE 1-13



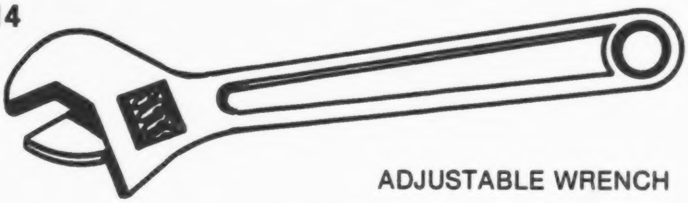
COMBINATION

a. Have an open end at one end and a box end at the other

b. The open end and the box end are the same size.

4. Adjustable wrench (FIG. 1-14)

FIGURE 1-14



ADJUSTABLE WRENCH

a. Has a screw which allows the jaws to change size

b. Sized according to length; also reflects how far jaws can be spread apart

c. Different brands may grip a hex bolt on either two or four sides

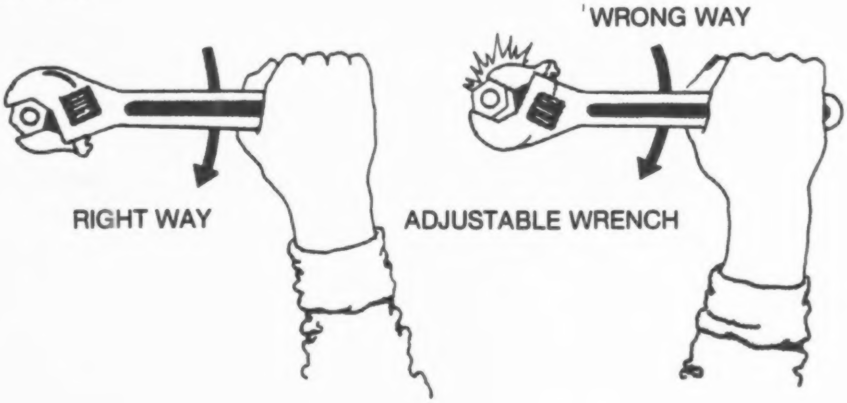
d. Has advantage of adjusting to different sizes

e. Has disadvantage of not gripping as solidly as box end wrenches, and unless properly adjusted and in good condition, may not grip as solidly as open-end wrenches

f. May become so worn that jaws slip (a worn adjustable wrench should be reconditioned)

g. When using an adjustable wrench, the pressure applied should always be against the larger, stationary, jaw. (FIG. 1-15)

FIGURE 1-15



ADJUSTABLE WRENCH

IV. Socket wrenches

A. Socket wrenches are among the most useful tools in all automotive work.

B. Socket wrenches are named because a cylindrical socket in the size of the bolt fits down over the bolt, much like a box end wrench.

C. The two basic parts of the socket wrench are the socket and the drive.

D. Socket wrenches are used in places that are not accessible by a common wrench.

E. Socket wrenches are used to save time in removing bolts, since the bolt can be removed faster with a socket and the appropriate drive.

F. Sockets are sized according to the size bolt head they fit and the size of drive they take.

G. Drives are sized according to the size of the square connection which fits into the back of the socket.

(NOTE: The most common size drives for auto body work are 3/8 inch and 1/2 inch. A 1/4 inch drive is also very useful for smaller bolts, such as used on interior and exterior trim.)

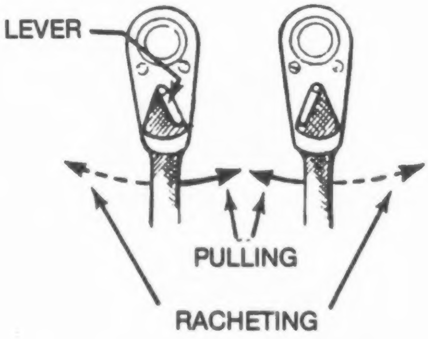
H. Maintenance

1. Sockets and drives should be kept free of dirt and grease.
2. Should be stored in a dry place to avoid rust
3. Ratchet drives can become worn and can be reconditioned if the ratchet starts to slip.

I. Safety

1. Rachet drives can turn both counter-clockwise and clockwise and the lever that switches the direction should be firmly placed all the way into its proper position (FIG. 1-16).

FIGURE 1-16



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2. Ratchet drives are sensitive and should not under any circumstance be used as a hammer or pry bar.

3. The exact size socket must always be used.

4. When using a socket on a damaged bolt head, be especially careful of the wrench slipping off.

5. Damaged sockets should be discarded, as they can slip off a bolt.

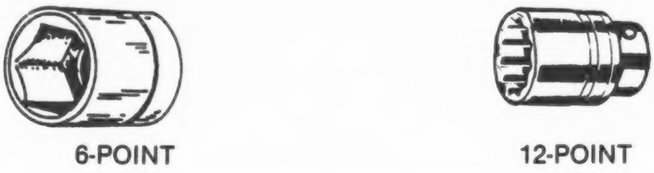
6. Always be sure the socket is completely over the bolt head. If the bolt head is so damaged that the socket cannot fit completely over the head, then use another method of removal.

J. Socket wrench-set components

1. Sockets

a. Come in 6- and 12-point styles (FIG. 1-17)

FIGURE 1-17



(NOTE: There is also an 8-point style, but it can only be used on square heads and is not in widespread use)

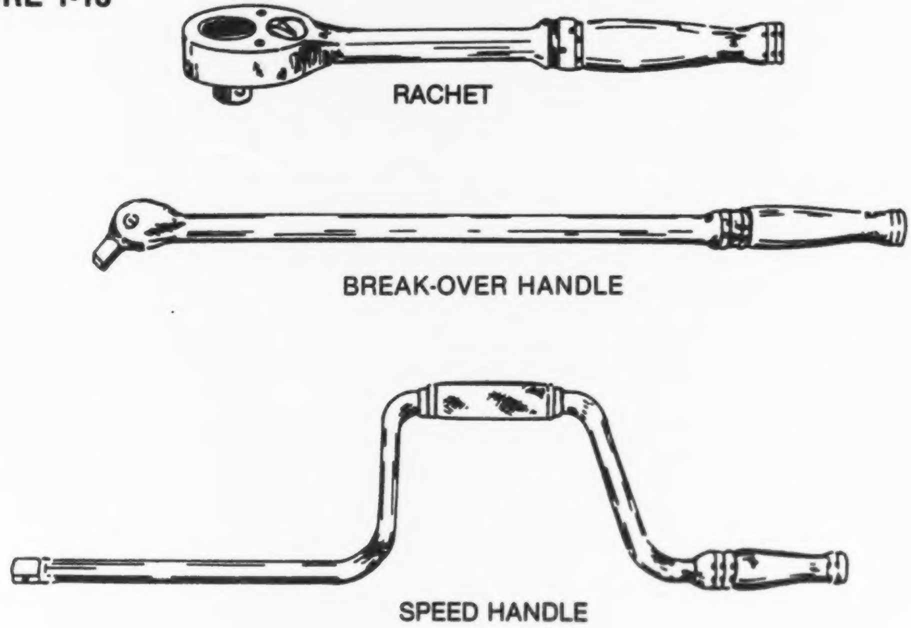
b. Come in shallow and deep-well lengths

c. Deep-well lengths are used on spark plugs, some bumper bolts, some special lug bolts, and in hard-to-reach places.

d. As with common wrenches, metric and USCS sizes are not interchangeable.

2. Drives (FIG. 1-18)

FIGURE 1-18



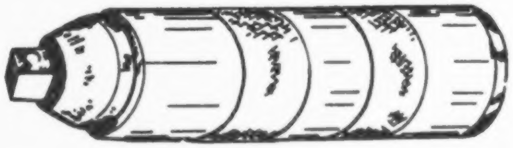
a. The rachet drive is the most common, allowing speed in removing or tightening bolts, since socket does not have to be removed from head of bolt.

b. Speed handles are even faster than rachet drives, but cannot be used on most hard-to-reach places.

c. Break-over handles are used when maximum leverage is required to loosen a bolt.

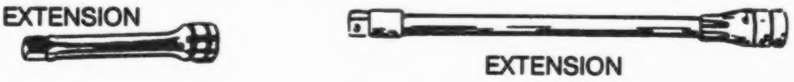
d. Impact drivers are special tools which take a socket and are used by driving a hammer down on top of the impact driver. The impact causes the driver to turn the bolt head. It is only used when other wrenches have failed and cutting the bolt off is not desired. (FIG. 1-19)

FIGURE 1-19



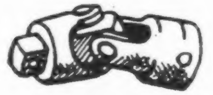
3. Extensions -- Come in many lengths and are used to allow access into recessed places where the drive would not fit. (FIG. 1-20)

FIGURE 1-20



4. Universal joints -- Are used in hard-to-reach places where straight-on access is not possible. (FIG. 1-21)

FIGURE 1-21



K. Torque wrenches (FIG. 1-22)

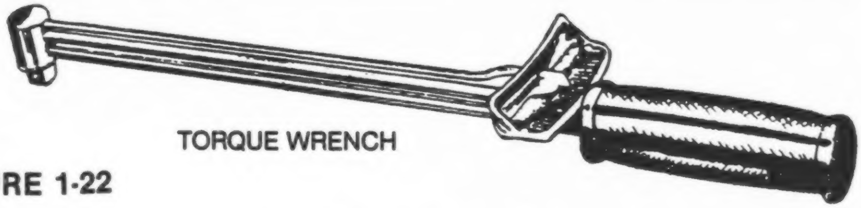


FIGURE 1-22

1. Come in a variety of styles
   a. Some use a micrometer gauge, which is set for the desired torque. When the torque is reached the wrench "clicks."
   b. Some show the pressure being applied with a gauge. The gauge may be of several different types.
2. Are used to show the amount of twisting force (torque) which is being applied in tightening the bolt
3. Are used as a drive for sockets

4. Are necessary in many auto body applications because the torque of certain bolts must meet manufacturer's specifications

   (NOTE: Specifications for the torque of bolts are extremely important. If too much torque is applied, the surfaces being joined will be damaged. If too little torque is applied, the bolt may work loose.)

5. Maintenance

   a. Care should be taken to keep torque wrenches free from dirt and grease.

   b. Special care should be taken to keep torque wrenches from rusting.

   c. NEVER use a torque wrench as anything but a torque wrench.

   d. Do not apply greater pressure than the gauge registers.

   e. When using a torque wrench, try not to use a universal joint in a socket-and-extension configuration. The universal joint may bind, giving an incorrect torque reading.)

V. **Pliers**

A. Pliers come in a wide variety of designs for many different purposes.

B. Pliers should not be used on bolts if a wrench will work.

(NOTE: An exception is the use of locking pliers on rounded-off bolt heads)

C. Maintenance

1. Pliers should be kept free of dirt and grease.

2. If the jaws of the pliers are held by a screw, the screw should be kept snug.

3. Pliers should be stored in a dry place to prevent rust.

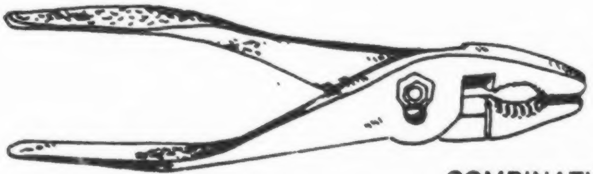
D. Safety

1. When working near electrical equipment, use pliers with insulated handles.

E. Types of pliers

1. Combination (FIG. 1-23)

FIGURE 1-23



COMBINATION PLIERS

a. So called because they have both notched and flat jaws, as well as a wire-cutting edge

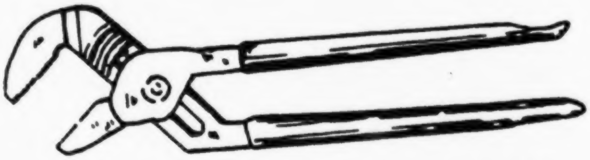
b. Have a moveable center bolt to change the size of the jaws

c. Are sized according to length, with the larger sizes capable of spreading larger

2. Rib joint pliers (FIG. 1-24)

(NOTE: Rib joint pliers are also known as interlocking grip pliers, tongue-and-groove pliers and Channellocks®)

FIGURE 1-24



RIB JOINT PLIERS

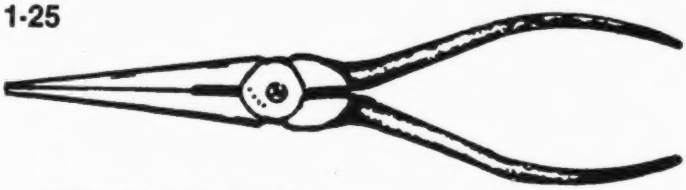
a. Have several locking channels below the jaw of the tool

b. Changing the channel in which the two jaws are aligned changes the size of the jaw.

c. Changing the size of the jaw allows the two surfaces on the jaws to remain parallel for better gripping action and less chance of damage to the object being gripped.

3. Needle-nosed pliers (FIG. 1-25)

FIGURE 1-25



NEEDLE NOSE PLIERS

a. Have long, tapering jaws, allowing them to reach into tight places

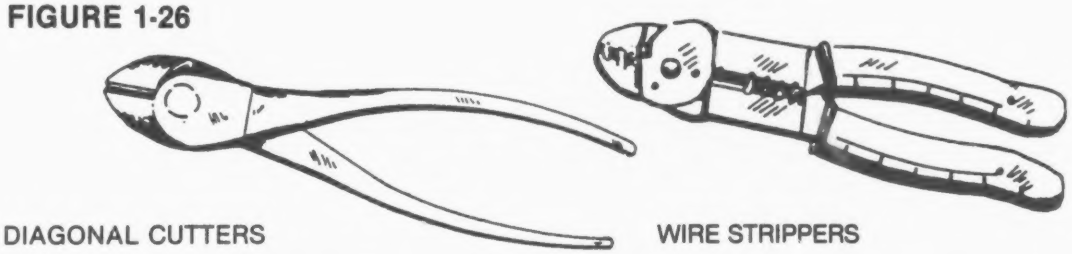
b. May be straight or curved

4. Cutting pliers

a. Come in a variety of styles for cutting wire

b. Styles include electrician's pliers (wire strippers) and diagonal cutters (FIG. 1-26)

FIGURE 1-26



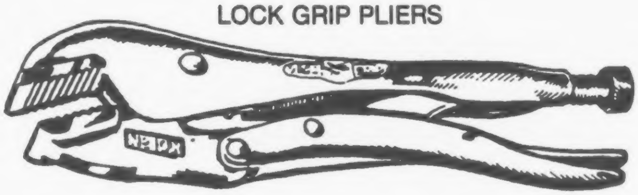
F. Locking pliers

1. Locking pliers have a special spring mechanism which allows them to lock onto what they are grasping.
2. Locking pliers come in a variety of styles and have wide usage in auto body work.
3. Locking pliers are adjustable, allowing the jaws to reach different sizes.
4. The adjustment is a screw on the stationary jaw of the pliers.
5. Are sized according to length
6. Maintenance
    a. Locking pliers should be kept free of dirt, grease and foreign matter.
    b. Locking pliers should be stored in a dry place to prevent rust.
7. Safety
    a. Do not use locking pliers when a wrench will work.
    b. Be very careful in using locking pliers around electrical equipment.
    c. When clamping or removing pliers, keep a proper grip on the handles. The handles snap together and snap apart with considerable force.

G. Types of locking pliers

1. Standard (FIG. 1-27)

FIGURE 1-27



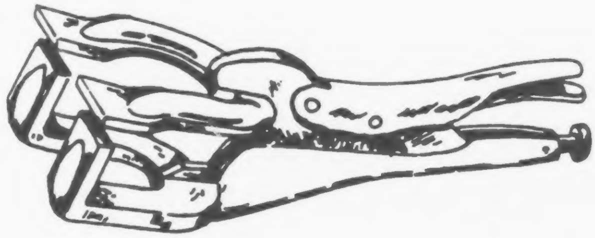
LOCK GRIP PLIERS

a. May have straight or curved jaws

b. Have many uses, but are most commonly used to remove rounded-off nuts, bolts and screws, or as clamps

2. Welding clamp (FIG. 1-28)

FIGURE 1-28



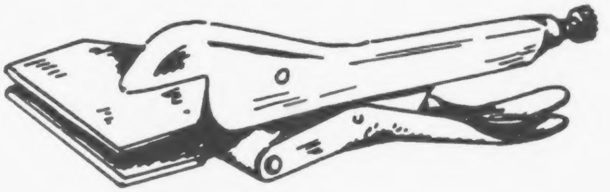
WELDING CLAMP

a. Used to hold panels together for welding

b. Large jaw has reach-over capability, allowing it to fit over seams or flanges

3. Sheet metal clamp (FIG. 1-29)

FIGURE 1-29



SHEET METAL CLAMP

a. Used to grab sheet metal for bending and shaping

b. Also used to grab and stretch upholstery

VI. Miscellaneous hand tools

A. Sheet metal cutters

1. Are used to cut sheet metal during repairs

2. Leave a clean, sharp edge for good alignment of replacement metal

3. Maintenance

a. Sheet metal cutters should be kept free or dirt and foreign matter.

b. Should be stored in a dry place to prevent rust

c. Bolt holding jaws together should be kept snug

d. If properly used, they will need re-sharpening infrequently.

e. If they need sharpening, special skill is needed to sharpen the edge in such a way it does not affect the tool's ability to cut a straight, clean line.

f. Use only on sheet metal

4. Safety

a. The snips are capable of cutting anything - respect them.

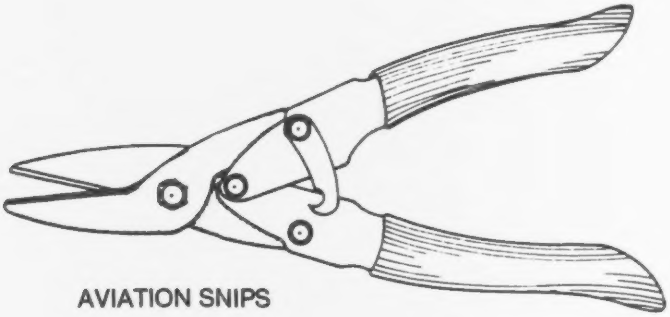
b. If cutting off a very small portion of some sheet metal, hold or clamp the small portion being cut off in place. When the small piece is cut off, the force of the snips can send the small piece flying toward you -- or toward an undamaged portion of the vehicle.

c. Always wear heavy gloves and safety glasses when working with metal snips. Be especially aware of the extremely sharp edges left behind on the cut metal.

B. Types of sheet metal cutters

1. Aviation snips (FIG. 1-30)

FIGURE 1-30



AVIATION SNIPS

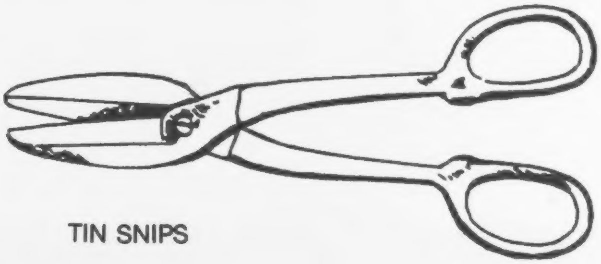
a. Used for cutting hard metal, such as stainless steel

b. Have a narrow body that allows the cut metal to pass freely over the snips

c. Come in right, left and straight cut

2. Tin snips (FIG. 1-31)

FIGURE 1-31



TIN SNIPS

a. Are larger than aviation snips

b. Allow for great leverage in cutting through metal

c. Come in right, left and straight cut

C. Chisels

1. Chisels are used to cut metal and are driven with a hammer.

2. Chisels come in a variety of styles for a variety of cutting operations.

3. Common chisels have some application to body work, but generally other cutting tools will be used.

4. Maintenance

    a. After a certain amount of use, the head of the chisel will mushroom. It must be ground off with a grinding wheel.

    b. The cutting edge may become dull and chip and must be ground back into shape with a grinding wheel.

    c. After a certain amount of maintenance with the grinding wheel, the chisel will reach a point of being too short or the edge too blunt and it should be discarded.

    d. Chisels should be kept free of dirt and grease and should be stored in a dry place to prevent rust.

5. Safety

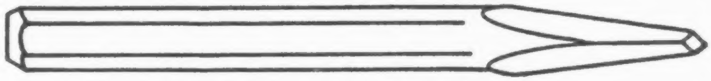
    a. Always wear heavy gloves and safety glasses when working with chisels.

    b. Grind down a mushroomed head immediately -- the mushroomed metal may fly off and injure you, or the hammer may more easily slip off the head.

6. Types of chisels

    a. Diamond-point chisel (FIG. 1-32)

FIGURE 1-32



DIAMOND POINT CHISEL

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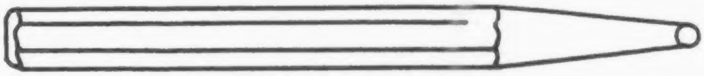
b. Round-nose chisel (FIG. 1-33)

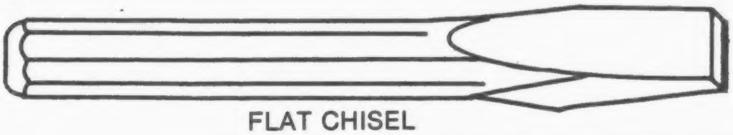
FIGURE 1-33



ROUND-NOSE CHISEL

c. Flat chisel (FIG. 1-34)

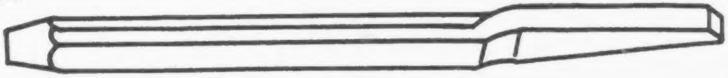
FIGURE 1-34



FLAT CHISEL

d. Cape chisel (FIG. 1-35)

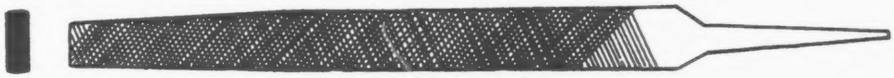
FIGURE 1-35



CAPE CHISEL

D. Files (FIG. 1-36)

FIGURE 1-36



DOUBLE-CUT FILE

1. Files are used to smooth and prepare metal surfaces.
2. Files have many rows of parallel teeth, which cut the metal.
3. Files are graded according to coarseness, from very coarse files to very fine files.
4. Files may be flat-surfaced, curved-surfaced, round, or triangular.

5. Files can be single-cut or double-cut. The double-cut file has two sets of cuts on the face of the file at an angle to each other, making the teeth pointed.

6. Files should be used with a handle. The handle is put on the file by placing it over the end and then tapping the handle down on a hard object.

7. Maintenance

   a. Files are especially sensitive to damage if not handled properly.

   b. Always store files away from other tools and remove and replace files from storage carefully.

   c. Files should be kept clean and free of dirt, grease and foreign matter.

   d. Files should be kept in a dry place to prevent rust.

8. Safety

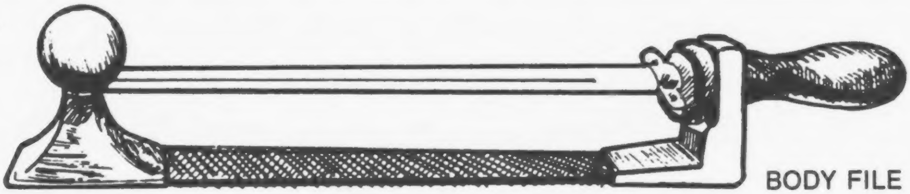
   a. Files are very brittle and should never be used as pry bars - the metal can shatter with dangerous results.

   b. Always wear safety *goggles* and heavy gloves when working with a file

   c. If using a body file (see below) relieve the tension on an adjustable file before putting it away and remove straight files from file holders. The tension may cause the file to snap on its own.

E. Body files (FIG. 1-37)

FIGURE 1-37



BODY FILE

1. Body files are similar to common shop files except they are designed to be used in holders.

2. Body files may use adjustable or fixed holders. Fixed holders use files with holes drilled in them and the file is screwed into the holder, giving it a slight bend. The adjustable file holder can be adjusted to bend the file so it will fit a curved surface.

3. There are several special body files used on particular portions of the vehicle, such as around windshields. Always use the right file for the job.

F. Punches

1. Punches have many applications for auto body work.

2. Punches are of various types for various purposes.

3. Punches are used with a hammer, like a chisel.

4. Maintenance

   a. A punch may eventually develop a mushroomed head, which should be ground off.

   b. The working end of the chisel should be kept free of nicks and foreign matter and can be "dressed up" with a grinding wheel.

   c. Punches should be kept free of dirt and grease and stored in a dry place to prevent rust.

5. Safety

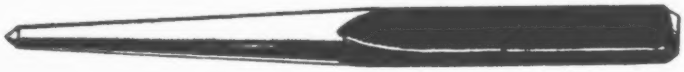
   a. Heavy gloves and safety glasses should always be worn when working with punches.

   b. Punches should be used with finesse rather than brute force - usually several light hits on the head will work better for all purposes than a heavy hit.

G. Types and uses of punches

1. Center punch (FIG. 1-38)

FIGURE 1-38



CENTER PUNCH

   a. Has a sharp pointed end

   b. Used to mark the location of drill holes and at the same time provide a small starting hole for the drill bit to keep it from wandering over the surface

   c. Used to mark parts before disassembly (for example, marking a notch on a cover plate to show which edge is the top edge)

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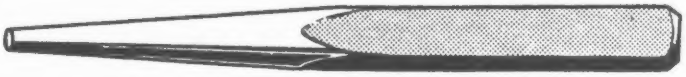
2. Starting punch (FIG. 1-39)

FIGURE 1-39



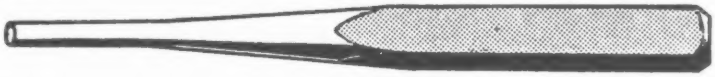
STARTING PUNCH

   a. Has a round, blunt end and a tapered shaft

   b. Used to provide the force to start driving out rivets and pins after the heads have been ground off

3. Pin punch (FIG. 1-40)

FIGURE 1-40



PIN PUNCH

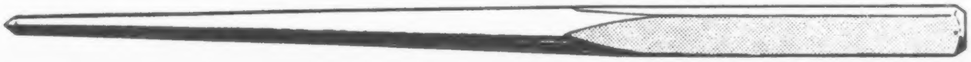
   a. Has a round, blunt end and the shaft is tapered in such a way that it can be driven about two inches or more through a hole

   b. Used to drive out rivets and pins after being broken loose with a starting punch

   (NOTE: In driving out a pin or rivet, the head of the pin or rivet is first ground or filed off.)

4. Aligning punch (FIG. 1-41)

FIGURE 1-41



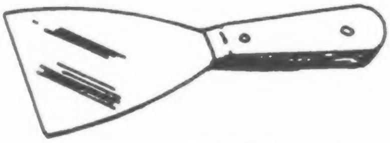
ALIGNING PUNCH

   a. Has a sharp end with a long, gently tapered shaft

   b. Placed through two or more holes to be lined up to keep them in line or to gently bring them into line

H. Putty knives (FIG. 1-42)

FIGURE 1-42

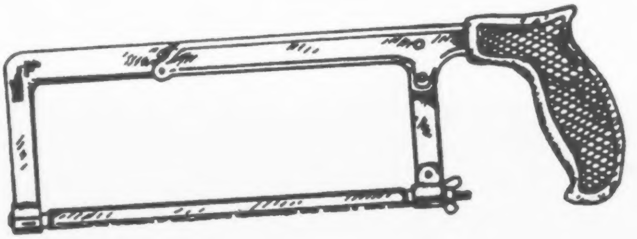


PUTTY KNIFE

1. Putty knives come in a variety of shapes with a variety of uses.
2. Uses include removing paint and undercoating, and applying plastic filler and caulking
3. Putty knives are sized according to the length and width of the blade.
4. Maintenance
   a. Keep putty knives free from dirt and grease
   b. If the cutting end is nicked they can be dressed up with a grinding wheel or a wire brush wheel.
5. Safety
   a. Use rubber gloves if removing paint with a chemical stripper
   b. Do not use to pry on objects
   c. Do not pull toward you - always push away from you

I. Hacksaw (FIG. 1-43)

FIGURE 1-43

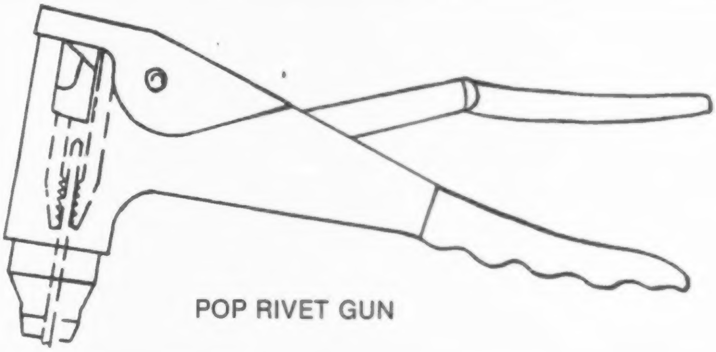


HACKSAW

1. The hacksaw is used for a variety of purposes in auto body, such as cutting off rusted bolts or cutting sheet metal.
2. If used to cut sheet metal, the sheet metal should be clamped between two pieces of wood and put into a vice. The wood and sheet metal are cut through at the same time.
3. The correct type of saw blade must be used for the type of metal being cut.
4. The saw is held firmly on each end and a smooth, even stroke is used. On the return stroke, lift the saw and do not let the teeth drag over the metal. The hacksaw blade cuts in one direction only.
5. Maintenance
    a. Keep the saw blade tight
    b. Do not use a dull blade - replace
    c. Keep blade and holder free from dirt and grease and store in a dry place to prevent rust
6. Safety
    a. Always wear safety glasses and heavy gloves when using a hacksaw - the blade can break.
    b. Be sure the object you are sawing is firmly secured

J. Pop rivet gun (FIG. 1-44)

FIGURE 1-44



POP RIVET GUN

1. The pop rivet (or blind rivet) gun has many applications in the auto body field.
2. The rivet gun works with pop rivets and is used to fasten panels together where the back of the panel is not accessible.

3. The rivet head is inserted into the head of the rivet gun and the shank is placed through the hole to be riveted. The gun trigger is then squeezed. The special construction of the rivet forms a head on the blind side of the rivet as the pressure is applied, then the stem breaks, leaving the rivet behind.

4. Maintenance

    a. Rivets and the rivet gun should be kept free of dirt and grease and stored in a dry place to prevent corrosion.

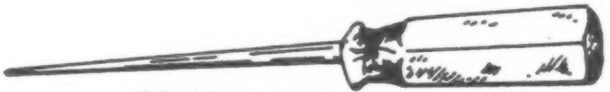
5. Safety

    a. Be sure the tip of the rivet gun is flush against the panel you are riveting

    b. Dispose of the stems of the rivets properly as they have a sharp end.

K. Scratch awl (FIG. 1-45)

FIGURE 1-45



SCRATCH AWL

1. Looks like a screwdriver with a sharp, pointed end

2. Used to make reference marks on sheet metal and other parts

3. Used to punch holes in very thin sheet metal when a rough-edged hole is acceptable

4. May be used to punch rough holes in thicker metal by tapping on the end with a hammer

    (NOTE: Use caution with this procedure. The scratch awl is not capable of withstanding heavy hammer blows without breaking.)

5. Maintenance

    a. Keep end sharp by dressing with a wire brush wheel

    b. Keep tool free of dirt and grease and store in a dry place to prevent rust

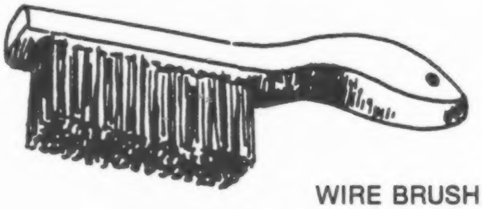
6. Safety

    a. Do not use as a pry bar

    b. Do not use as an aligning punch

L. Wire brushes (FIG. 1-46)

FIGURE 1-46

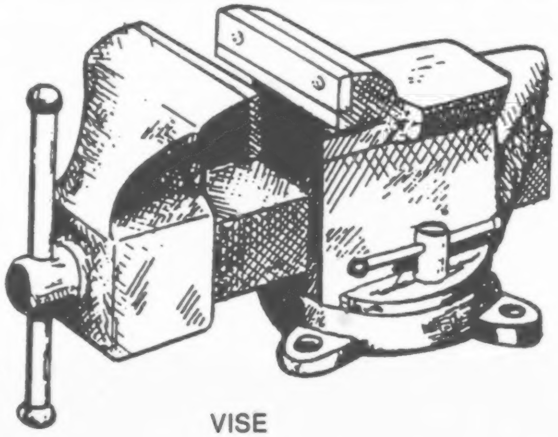


WIRE BRUSH

1. Come in a variety of styles with many auto body applications
2. Used to remove various coatings, dirt, and rust from vehicle panels
3. Maintenance
    a. Keep clean and free of grime
    b. Store in a dry place to prevent rust
4. Safety
    a. Use heavy gloves when working with a wire brush, since even a light scrape across the hands can cause injury

M. Vise (FIG. 1-47)

FIGURE 1-47



VISE

1. The bench vice has general use in the body shop.
2. Is used to hold parts in place while working on them

3. Can be used on objects with delicate surfaces by using soft metal covers, inserted over the steel faces of the jaws

4. Maintenance

    a. Keep vise tightly secured to bench

    b. Keep faces of jaws clean and free from dirt and grease

MODULE: INTRODUCTION TO AUTO BODY

UNIT III: HAND TOOLS

LESSON TWO: AUTO BODY HAND TOOLS

I. **Using Auto Body Hand Tools**

A. In addition to general hand tools the body shop technician will use many tools which are specifically designed for auto body work.

B. Most of these tools are designed for use in contouring damaged metal panels.

C. Maintenance

1. Unless otherwise stated below, the general maintenance of auto body hand tools is as follows:

a. Keep the faces of hammers, dollies and spoons free from dirt and grease.

b. Store auto body hand tools in a dry place to prevent rust.

2. DO NOT USE auto body hand tools except for their intended purpose. They are too expensive to be damaged by using them for jobs that less-expensive common hand tools were made.

3. For all tools with wooden handles, such as many body hammers, make sure the head is secure on the handle before use.

D. Using body hammers

1. The right body hammer must be used for the job and mastery of using the hammer with the dolly must be achieved (See Module 3: "Panel Repairs").

2. In using body hammers, the blows struck should be light and even and not heavy. If the metal is workable, it will come back into shape with finesse instead of brute force.

3. In striking a blow, the body hammer should be held loosely in the hand and it should spring back from the metal as the blow is struck.

II. **Body hammers**

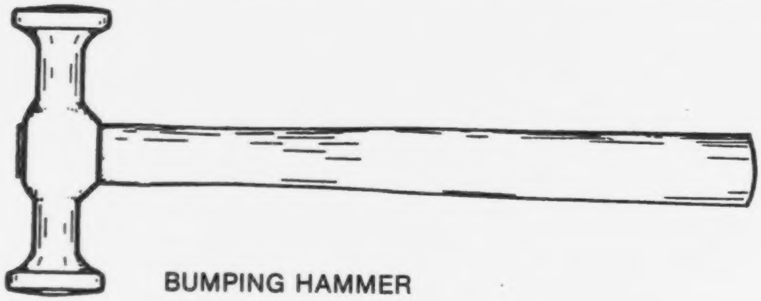
A. Body hammers are the most important tools in working with damaged metal body panels.

B. Body hammers are designed to bring damaged metal back to its original contours.

C. Body hammers come in a wide variety of styles for a wide variety of applications.

D. Bumping and dinging hammers (FIG. 2-1)

FIGURE 2-1



BUMPING HAMMER

1. A bumping or a dinging hammer is a body hammer with two smooth faces.

2. Bumping and dinging hammers are used to lower high spots on a damaged panel, and are usually used with a dolly.

3. A bumping hammer is distinguished from a dinging hammer by its weight. A bumping hammer is larger, weighing from 14 ounces to 2.5 pounds while a dinging hammer weighs from seven to 12 ounces.

4. A bumping hammer is used to rough out a badly damaged panel and can be used as a dolly to back up a dinging hammer or another bumping hammer.

5. A bumping hammer is also used to shrink welds (driving the weld down flush with the surrounding metal).

6. The bumping hammer is used to align heavier gauge sheet metal that has been bent out of alignment.

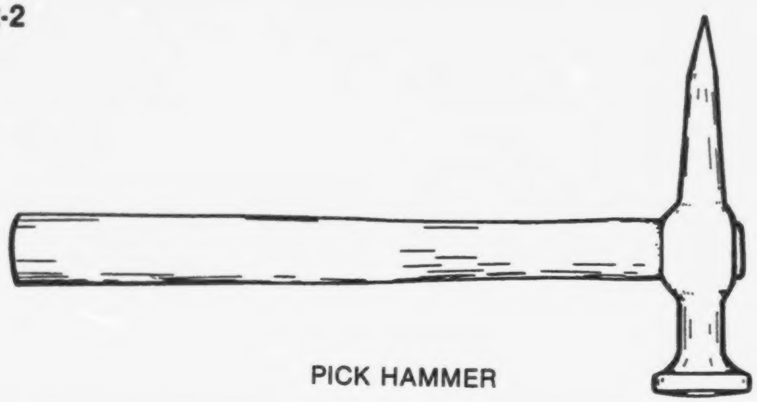
7. Both the bumping and dinging hammers have high-crowned faces.

8. Dinging hammers are used on areas where the damage is not severe.

9. Both dinging and bumping hammers may have a variety of faces, with one round and one square face, or two round faces.

E. Pick hammers (FIG. 2-2)

FIGURE 2-2



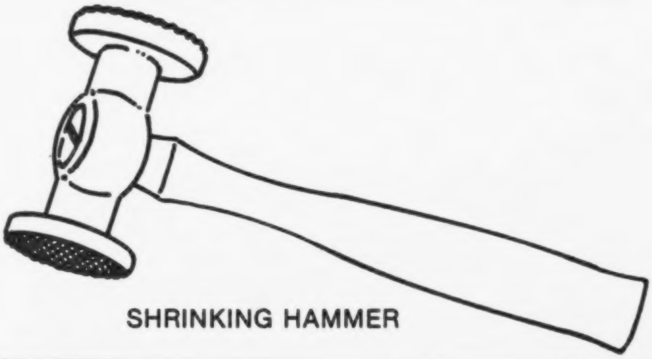
PICK HAMMER

1. Pick hammers have a tapered, blunt chisel on one end of the head, and usually a bumping face on the other end.
2. The length of the pick determines the type and use of the pick hammer.
3. Pick hammers are used in roughing out metal.
4. Pick hammers are used to lower a crease or a small dent in the metal.
5. Pick hammers may be used with or without a dolly.

(NOTE: Body hammers with two bumping faces are called bumping or dinging hammers, depending on the weight. Body hammers with a pick hammer on one side are called pick hammers, even if they have a bumping face on the other side.)

F. Shrinking hammers (FIG. 2-3)

FIGURE 2-3



SHRINKING HAMMER

1. A shrinking hammer is another type of body hammer used to shrink metal.

2. Shrinking hammers are distinguished by having two serrated faces, both round, or one round and one square.

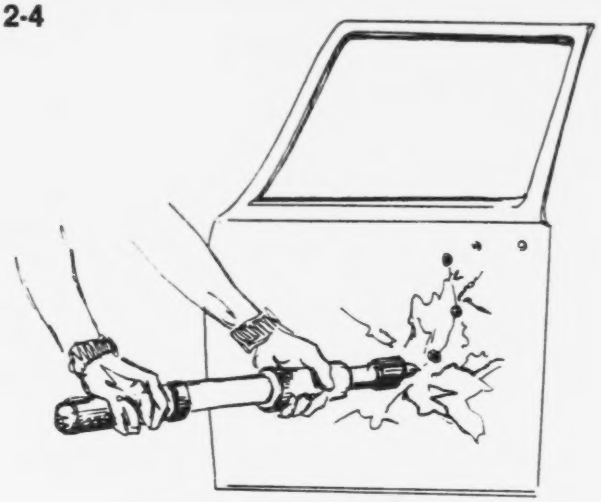
3. They are used to bring lightly stretched metal back into shape.

4. The serrated edge "grips" the metal, and as the hammer lowers a high spot (always backed by a dolly) the metal is compressed back into shape.

III. Miscellaneous auto body hand tools

A. Slide hammers (FIG. 2-4)

FIGURE 2-4



SLIDE HAMMER

1. Slide hammers are one of the most useful tools available in straightening panel damage.

2. The slide hammer has a weight that can be rammed against a stop at either end of a cylinder that the weight slides along.

3. Using various attachments, the slide hammer can pull or push on a damaged panel.

4. The most common use of the slide hammer is to drill a small hole into a panel which must be pulled out, then fasten a sheet metal screw into the hole. The slide hammer is them attached to the sheet metal screw and the slide weight is used to pull the panel outward.

5. The advantage of the slide hammer is that the back of the panel does not have to be accessible.

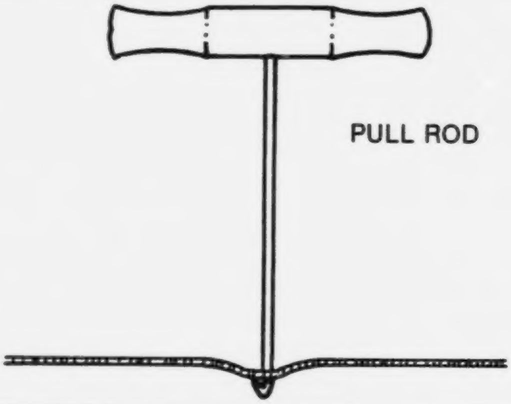
100

6. The slide hammer must be handled carefully, again using finesse instead of brute force. In the proper operation of the slide hammer, two or more screws will be fastened to the panel and the slide hammer will be moved from one to the other as the pull progresses.

7. The slide hammer can also be used with a suction cup attachment to pull out a panel, or with various hooks to grab onto the edge of a panel, or with attachments which allow it to push against a panel.

B. Pull rods (FIG. 2-5)

FIGURE 2-5



1. Pull rods are used in much the same way as a slide hammer, but are used on smaller areas of damage.

2. To use a pull rod, a hole is drilled in the damaged panel and the hooked end of the pull rod is inserted into the hole. The technician then pulls on the handle of the pull rod in an attempt to pull the dent out.

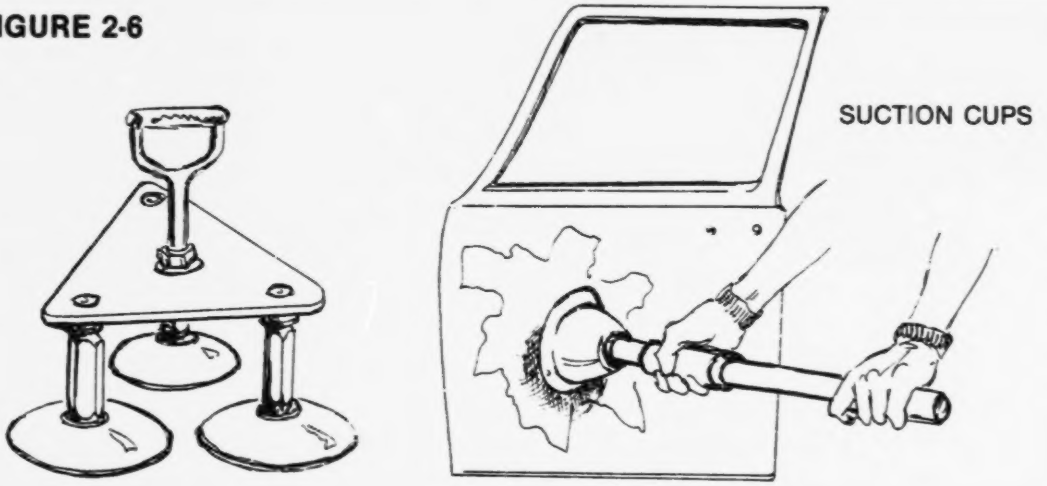
3. Often, more than one pull rod is used at the same time to distribute the pressure of the pull over a broader area. However, the holes drilled must be close enough together than the rods can all be grasped firmly at the same time.

4. In using both pull rods and slide hammers, a bumping hammer may be used to tap on the edges of the depressed area to help relieve the stress in the metal and make the pull easier.

5. One disadvantage to pull rods and slide hammers is that they raise the metal around the rim of the drilled holes and this metal must then be shrunk or filed off.

C. Suction cups (FIG. 2-6)

FIGURE 2-6



1. Suction cups can be used to pull out large, shallow dents, where the metal has not buckled

2. The suction cups are wetted and the surface wetted, then pushed in at the center of the depression, expelling the air from the cup.

3. A configuration of two or three suction cups is often used.

4. Suction cups can also be used with frame straightening equipment. For pulls on the hood, roof and deck, a motor hoist can be used with the suction cups

5. If the suction cups work properly and the metal has not been upset, then the dent should "pop" out.

D. Dollies

1. Dollies are used together with body hammers in straightening panel damage where the back of the panel is accessible.

2. The dolly is held in the hand against the backside of a low spot, while the hammer picks, dings, bumps, or shrinks the high spot on the other side.

3. There are two types of hammering with a dolly (See Module 3: "Panel repairs.")

   a. Off-the-dolly hammering

   b. On-the-dolly hammering

4. Dollies come in various shapes, to fit the various contours of panels, trying to bring the panel back to its original contours.

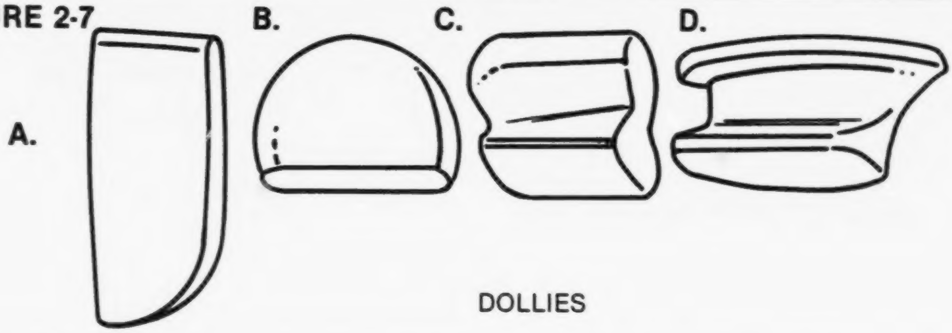
5. Dollies are made of high-grade steel and are available with high, medium, low and flat crowns, or a combination of several crown working faces.

6. They are well-balanced for ease of handling and control.

   (NOTE: Working faces should be kept smooth, free from tar, undercoating and nicks to avoid distorting and further damaging the surfaces being repaired.)

7. Examples of dollies (FIG. 2-7)

FIGURE 2-7



DOLLIES

   a. Toe dolly

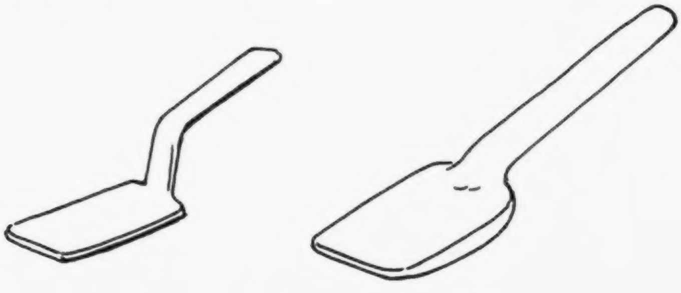
   b. Heel dolly

   c. General purpose dolly

   d. Anvil dolly

E. Body spoons (FIG. 2-8)

FIGURE 2-8



BODY SPOONS

1. Body spoons are also called dolly spoons because they are used in much the same way as a dolly.

2. Body spoons are essentially dollies with handles which allows them to be used in places you cannot reach with a dolly.

3. Body spoons are also used to spread the blow of the hammer over a large area by using a flat body spoon that can be laid down along a long ridge.

4. Are also used as heavy-duty prying of driving tools, prying or driving against low spots to work them out.
5. Are used in spring hammering, where the spoon is laid across a high crown or ridge and a hammer is then driven down on top of the spoon.

F. Special pry bars

1. Some pry bars are made which can get into hard-to-reach places.
2. For example, some can be pushed up inside of drain holes to get access to the back of a panel where no other access is possible.
3. Your instructor can demonstrate any special pry tools you have in your shop.

G. Trim tools

1. In addition to working with damaged metal, there are many special tools which must be used to remove trim, such as trim around windows, accent trim and interior trim. The special trim tools are discussed in detail in Module 5: "Interior and Exterior Trim."

MODULE: INTRODUCTION TO AUTO BODY

UNIT III: HAND TOOLS

UNIT III TEST

PART I–HAMMERS

I. Match the name of the tool in the left column with the illustration in the right column.

_____1. Ball peen hammer

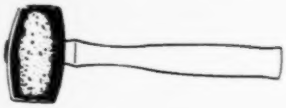
_____2. Rubber mallet

_____3. Plastic tip hammer

_____4. Brass face hammer

_____5. Soft face hammer

C.



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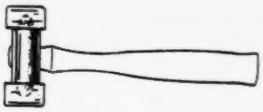

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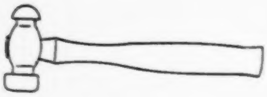

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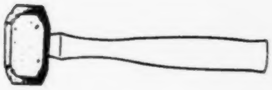

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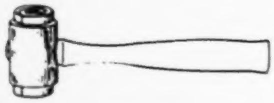


II. Select the best answer from the choices listed.

_____6. Used to strike surfaces which could be damaged by using a steel hammer, and often used on mechanical parts: (a) ball peen hammer, (b) rubber mallet, (c) plastic tip hammer, (d) brass face hammer, (e) soft face hammer.

_____7. Used on mechanical parts which must not be marred, such as suspension parts: (a) ball peen hammer, (b) rubber mallet, (c) plastic tip hammer, (d) brass face hammer, (e) soft face hammer.

_____8. Used to rough out metal and drive punches and chisels: (a) ball peen hammer, (b) rubber mallet, (c) plastic tip hammer, (d) brass face hammer, (e) soft face hammer.

_____9. Used to rough out metal panels which could be damaged by using a steel hammer: (a) ball peen hammer, (b) rubber mallet, (c) plastic tip hammer, (d) brass face hammer, (e) soft face hammer.

_____10. Used on surfaces which are extremely vulnerable to damage, such as chrome trim: (a) ball peen hammer, (b) rubber mallet, (c) plastic tip hammer, (d) brass face hammer, (e) soft face hammer.

PART II--SCREWDRIVERS

I. Match the name of the tool in the left column with the illustration in the right column.

_____11. Standard tip screwdriver

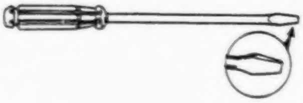
_____12. Phillips® screwdriver

_____13. Clutch head screwdriver

_____14. Torx® screwdriver

_____15. Offset screwdriver

C.



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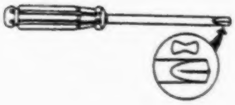

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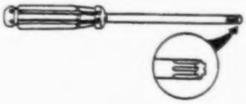

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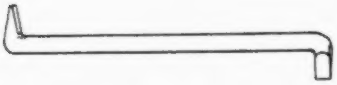

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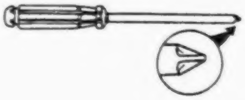


PART III–WRENCHES

I. Match the name of the tool in the left column with the correct illustration.

_____16. Open-end wrench

_____17. Box end

_____18. Combination

_____19. Adjustable wrench

_____20. Socket

_____21. Rachet

_____22. Speed handle

_____23. Breakover

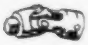
_____24. Impact driver

_____25. Socket drive extension

_____26. Socket universal joint

_____27. Torque wrench

A.



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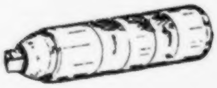

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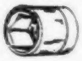

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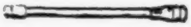

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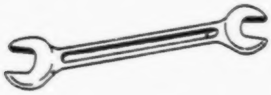

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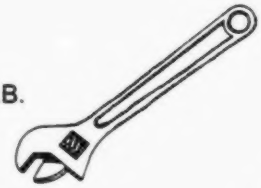

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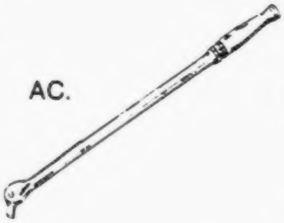

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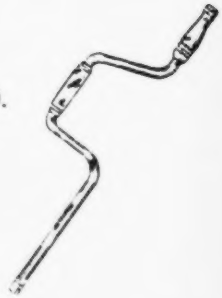

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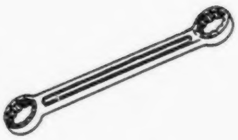
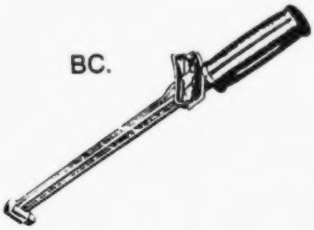


BC.



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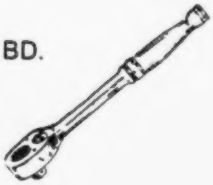

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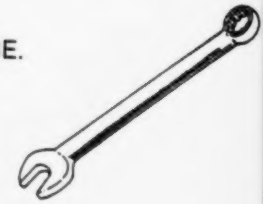


II. Select the best answer from the choices listed.

_____28. A wrench with the same sized opening at each end, one of which grips on two sides and the other on all sides or edges: (a) open-end wrench, (b) box-end wrench, (c) combination wrench, (d) adjustable wrench, (e) torque wrench.

_____29. Jaws change size for different size bolts or nuts: (a) open-end wrench, (b) box-end wrench, (c) combination wrench, (d) adjustable wrench, (e) torque wrench.

_____30. A wrench with a different sized opening at each end, used on four-sided bolts or in places where there is not enough room for a box-end wrench: (a) open-end wrench, (b) box-end wrench, (c) combination wrench, (d) adjustable wrench, (e) torque wrench.

_____31. A wrench with a different sized opening at each end that grips a bolt or nut on all sides or edges: (a) open-end wrench, (b) box-end wrench, (c) combination wrench, (d) adjustable wrench, (e) torque wrench.

_____32. Used with a hammer to remove bolts that cannot be removed by other means and which should not be cut off: (a) impact driver, (b) socket-drive extensions, (c) socket universal joints, (d) pile driver, (e) torque wrench.

_____33. Used to allow access into recessed places where the drive would not fit: (a) impact driver, (b) socket-drive extensions, (c) breakover, (d) pile driver, (e) torque wrench.

_____34. Used when maximum leverage is required on a bolt or nut: (a) socket wrench, (b) rachet, (c) speed handle, (d) breakover, (e) pile driver.

_____35. Used in hard-to-reach places where straight-on access is not possible: (a) socket wrench, (b) rachet, (c) speed handle, (d) breakover, (e) socket universal joint.

_____36. Can turn both counter-clockwise and clockwise by flipping a small switch on the tool: (a) socket wrench, (b) rachet, (c) speed handle, (d) breakover, (e) pile driver.

_____37. Used to measure the twisting force which is being applied in tightening a nut or bolt: (a) impact driver, (b) socket-drive extensions, (c) socket universal joints, (d) pile driver, (e) torque wrench.

_____38. Allows great speed in removing bolts and nuts but cannot be used on some hard-to-reach places: (a) socket wrench, (b) rachet, (c) speed handle, (d) breakover, (e) pile driver.

PART IV--PLIERS AND CUTTERS

I. Match the name of the tool in the left column with the correct illustration.

_____39. Combination pliers

_____40. Rib-joint pliers

_____41. Needle-nosed pliers

_____42. Electrician's pliers

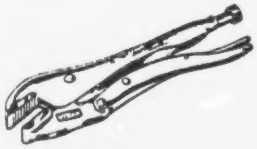
_____43. Diagonal cutters

_____44. Standard locking pliers

_____45. Welding clamp

_____46. Sheet metal clamp

A.



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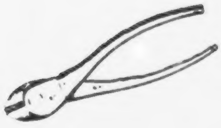

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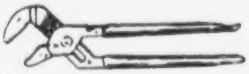

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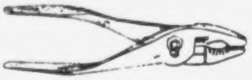

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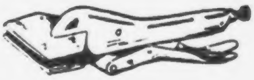

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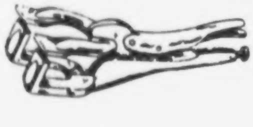

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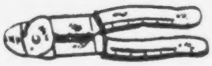

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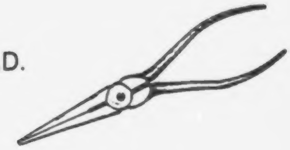


PART V—MISCELLANEOUS HAND TOOLS

I. Match the name of the tool in the left column with the correct illustration.

_____47. Aviation snips

_____48. Tin snips

_____49. Diamond point chisel

_____50. Round-nose chisel

_____51. Flat chisel

_____52. Cape chisel

_____53. Flat-surface file

_____54. Body file

_____55. Center punch

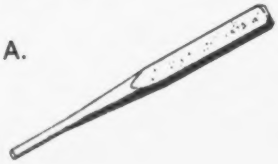
_____56. Starting punch

_____57. Pin punch

_____58. Aligning punch

_____59. Scratch awl

A.



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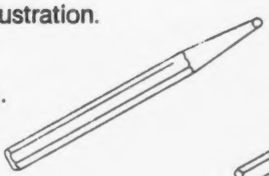

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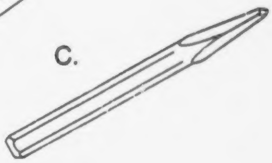

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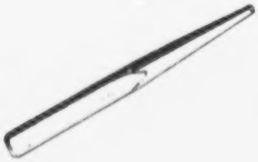

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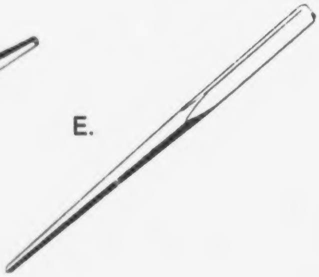

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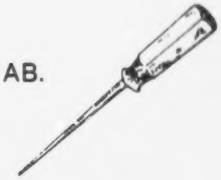

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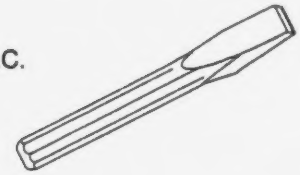

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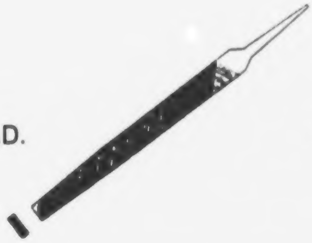

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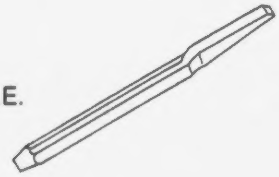

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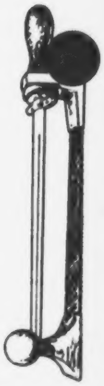

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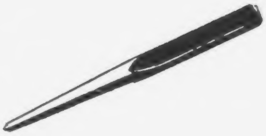

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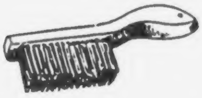

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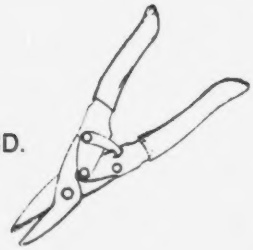

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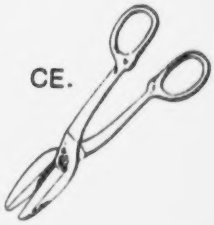


PART VI—HAND TOOL MAINTENANCE AND SAFETY

I. Mark a T on the test or the answer sheet if the statement is true and an F if the statement is false.

_____60. It is normal for tools to be dirty and greasy so cleaning them is not necessary.

_____61. It is important to store tools in a dry place to prevent rust.

_____62. It is normal for wooden handles to be a little loose on tools with wooden handles.

_____63. Any flat-surfaced hammer should only be struck flat against the surface struck.

_____64. The head of a screwdriver should match both the type and the size of the screw being turned.

_____65. A screwdriver works well as a punch.

_____66. It is a good idea to save wrenches with distorted jaws because they may fit a distorted bolt.

_____67. It is unnecessary to use metric wrenches if you have a full set of fractional-inch wrenches.

_____68. Except for using locking pliers on damaged bolts, you shouldn't use pliers on bolts.

_____69. When working near electrical equipment, always use pliers with insulated handles.

_____70. When working with metal snips, always wear safety glasses and heavy gloves.

_____71. Whenever striking a hammer against a metal surface, you should wear safety glasses, unless the metal is in a vice.

_____72. When the head of a chisel mushrooms, you should discard it.

_____73. When working with chisels, you should always wear safety glasses and heavy gloves.

_____74. When working with files or hacksaw blades, you should always wear safety glasses and heavy gloves.

_____75. When working with punches, you should wear safety glasses and heavy gloves.

_____76. A punch should be struck with a heavy hammer blow.

_____77. When using a scraper to remove paint with a chemical stripper, you should wear heavy gloves.

_____78. When working with a wire brush, you should not use heavy gloves, because you need to have a good feel for the way the brush is working.

(NOTE: Completion of this portion of the unit test is the evaluation for Competency C1 "Demonstrate safe use and maintanence of general hand tools." Of the 78 questions, *a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this portion of the test.)*

PART VII--AUTO BODY HAND TOOLS

I. Match the name of the tool in the left column with the correct illustration.

_____79. Bumping hammer

_____80. Pick hammer

_____81. Shrinking hammer

_____82. Slide hammer

_____83. General purpose dolly

_____84. Heel dolly

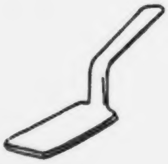
_____85. Toe dolly

_____86. Anvil dolly

_____87. Body spoon

_____88. Pull rod

_____89. Suction cup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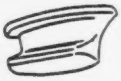
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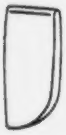
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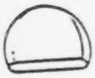
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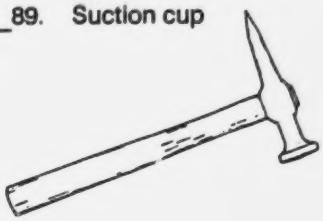
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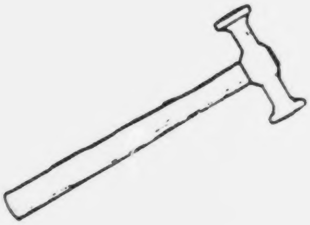
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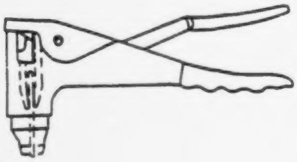
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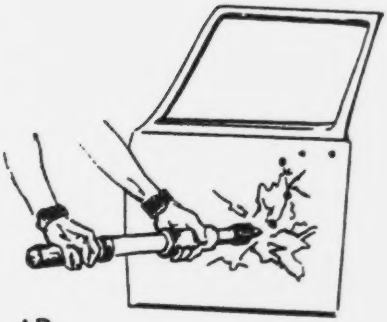
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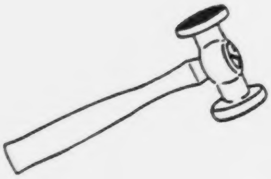
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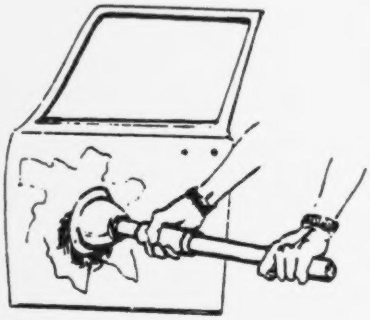
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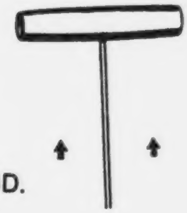
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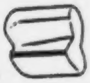

BE.

II. Match the description of the tool in the left column with the name of the tool in the right column.

_____90. Used as a dolly in places where a dolly cannot reach

_____91. Has a weight which can be rammed against a stop at either end in order to pull or push on a damaged panel

_____92. Held against the back side of a low spot

_____93. Used to lower high spots on a damaged panel and weighs 14 ounces to 2.5 pounds

_____94. Used to lower a crease or a small dent and has a blunt chisel on one end of the head

_____95. Used to lower high spots on a damaged panel and weighs seven to 12 ounces

_____96. Has a serrated edge with grips the metal and is used to bring lightly stretched metal back into shape

_____97. Used to pull out damage by wetting it and pushing it against the damaged panel until the air is forced out

_____98. Used to pull out damage by inserting it through a drilled hole

A. Suction cup

B. Pick hammer

C. Dolly

D. Dinging hammer

E. Body spoon

AB. Pull rod

AC. Slide hammer

AD. Ball peen hammer

AE. Shrinking hammer

BC. Bumping hammer

(NOTE: Completion of this portion of the unit test is the evaluation for Competency C2 "Demonstrate safe use and maintanence of auto body hand tools." Of the 20 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this portion of the test.)

ANSWERS TO UNIT III TEST

PART I.

1. D
2. C
3. A
4. B
5. E
6. C
7. D
8. A
9. B
10. E

PART II.

11. C
12. E
13. A
14. D
15. B

PART III.

16. E
17. AE
18. BE
19. AB
20. C
21. BD
22. AD
23. AC
24. B
25. D
26. A
27. BC

28. C
29. D
30. A
31. B
32. A
33. B
34. D
35. E
36. B
37. E
38. C

PART IV.

39. D
40. C
41. AD
42. AC
43. B
44. A
45. AB
46. E

PART V.

47. CD
48. CE
49. C
50. B
51. AC
52. AE
53. AD
54. BC
55. BD
56. D
57. A
58. E
59. AB

PART VI.

60. F
61. T
62. F
63. T
64. T
65. F
66. F
67. F
68. T
69. T
70. T
71. F
72. F
73. T
74. T
75. T
76. F
77. F
78. F

PART VII.

79. AB
80. E
81. AE
82. AD
83. BE
84. D
85. C
86. B
87. A
88. BD
89. BC

90. E
91. AC
92. C
93. BC
94. B
95. D
96. AE
97. A
98. AB

MODULE: INTRODUCTION TO AUTO BODY

UNIT IV: POWER TOOLS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify power tools and equipment used in auto body repair and know the proper use of the tools and equipment. Mastery will be evidenced by scoring ________ percent on the unit test and by demonstrating safe practices whenever using power tools.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit the student should be able to:

Lesson 1:

I. Demonstrate the application of general principles of use and safety for electric and pneumatic hand tools (Competency C3, Part I of Unit IV test)

II. Demonstrate the safe use and maintenance of power drills (Competency C3, Part II of Unit IV test)

III. Demonstrate the safe use and maintenance of power sanders and polishers (Competency C3, Part II of Unit IV test)

IV. Demonstrate the safe use and maintenance of power wrenches and cutters (Competency C3, Part II of Unit IV test)

V. Demonstrate the safe use and maintenance of miscellaneous power tools (Competency C3, Part II of Unit IV test)

Lesson 2:

I. Demonstrate the safe use and maintenance of an air compressor (Competency C4, Part III of Unit IV test)

II. Identify general principles of using and maintaining hydraulic equipment (Competency C4, Part III of Unit IV test)

III. Demonstrate the safe use and maintenance of hydraulic body jacks (Competency C4, Part III of Unit IV test)

IV. Demonstrate the safe use and maintenance of frame straightening equipment (Competency C4, Part III of Unit IV test)

MODULE: INTRODUCTION TO AUTO BODY

UNIT IV: POWER TOOLS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

   1. Lesson 1: Power hand tools

      a. Information outline

   2. Lesson 2: Pneumatic and hydraulic equipment

      a. Information outline

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

I. This unit should be self-explanatory. Due to safety considerations, many common power tools should be demonstrated to the students.

REFERENCES USED IN WRITING THIS UNIT

1. Blackhawk Automotive. *New Science of Unibody Repair.* Blackhawk Automotive. Milwaukee, WI. 1984.

2. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

3. Czapskie, George S., et. al. *Auto Body Repair.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1977.

4. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL. 1984.

5. Foutes, William. *Diesel Mechanics: Fundamentals.* Mid-America Vocational Curriculum Consortium, Inc. Stillwater, OK. 1982.

6. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

7. Scharff, Robert. *Motor Auto Body Repair.* Delmar Publishers, Inc. Albany, NY. 1988.

8. Toboldt, Bill. *Auto Body Repairing and Repainting.* The Goodheart-Willcox Co. Inc. South Holland, IL. 1982.

MODULE: INTRODUCTION TO AUTO BODY

UNIT IV: POWER TOOLS

LESSON ONE: POWER HAND TOOLS

I. **Principles of using power hand tools**

A. Electric hand tools

(NOTE: Electric hand tools are still in use in the body shop, but some have been replaced by pneumatic {air-operated} equipment, which is usually lighter.)

1. Electric tools are driven by an electric motor.

2. Using electrical equipment is a matter of common sense and using good safety practices.

3. Safety

    a. As with any electrical devices, be aware of the dangers of electric shock

    b. Always check that the power cord will not be damaged by the operation of the equipment and do not run over power cords with any heavy object

    c. Always check that the power cord is not frayed or worn

    d. Always make sure electric equipment is equipped with a grounded plug and is used only in a grounded receptacle

    e. Keep hands and clothing away from moving parts of electrical equipment

    f. When using sanders, always wear a particle mask

    g. When using grinders, always wear safety *goggles*

4. Maintenance

    a. Some electric equipment must be oiled occasionally. Check the service manual of the equipment you are using.

    b. Electrical equipment should be kept free of dirt and grease and should be stored in a dust-free, dry place.

B. Pneumatic hand tools

1. Pneumatic tools are tools powered by compressed air.

2. Most body shops prefer using pneumatic tools over electric tools.

3. Pneumatic tools are lighter than electric tools.

4. Pneumatic tools are not damaged by overloading or stalling.

5. All shops will have compressed air available, because a shop must have compressed air for spraying operations.

6. Although there are dangers associated with compressed air, the dangers are not as great as those associated with electricity.

7. Safety precautions for pneumatic tools

   a. Do not operate air tools other than for their intended purpose.

   b. Do not operate air chisels without a chisel in them.

   c. Do not point a blowgun at anyone.

   d. When using a blowgun, beware that the compressed air can propel dust at a high enough speed to put out an eye.

   e. Do not look into the air-outlet valve or nozzle of any piece of air-powered equipment.

   f. Never grab the moveable portion of an air-powered tool with your hand when it is hooked up to the air line.

   g. When working on pneumatic tools, always disconnect them from the air supply.

8. Maintenance of pneumatic equipment

   a. Before an air tool is used, three or four squirts of flushing oil should be applied to the air inlet to flush any dirt or moisture from the rotor and to lubricate the moving parts.

   b. Pneumatic equipment should be kept free of dirt and grease and should be stored in a dust-free, dry place.

   c. Care should be taken that no foreign matter enters the nipple opening of the couplings on pneumatic equipment.

   d. Do not use flushing oil around an open flame - the flushing oil is flammable.

9. The two basic designs of pneumatic hand tools

   a. Rotary -- The air drives a rotor (turbine) which spins a shaft and provides the power.

   b. Reciprocating -- The air drives a piston which is forced back and forth by the compressed air.

   (NOTE: The exceptions to the above two classes are blow guns and paint spraying equipment, which use a direct stream of air.)

10. Pneumatic couplings

a. Pneumatic equipment is connected to air supply equipment through quick couplers.

b. The quick coupler is on the end of the air supply hose.

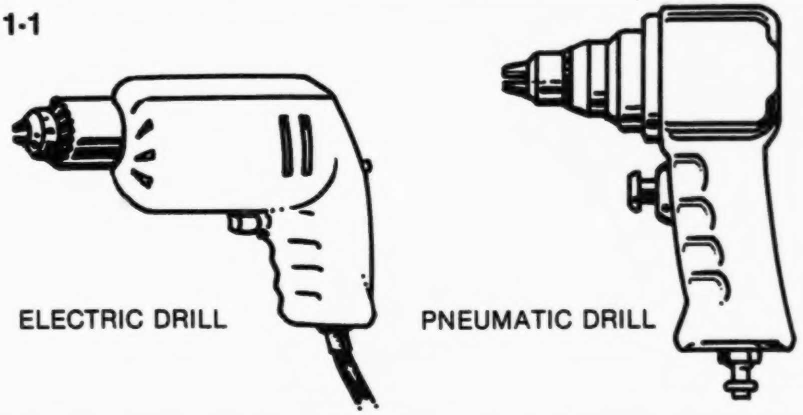
c. The quick coupler connects into a nipple on the equipment.

d. On some tools the manufacturer recommends a short leader hose be attached to the tool and the nipple installed at the end of the leader hose.

e. The quick coupler operates by pulling back a collar on the coupler, which allows the nipple to be inserted into the coupler. When the collar is released, it locks the nipple into the coupler.

II. Drills (FIG. 1-1)

FIGURE 1-1



A. Electric drills can be used interchangeably with pneumatic drills.

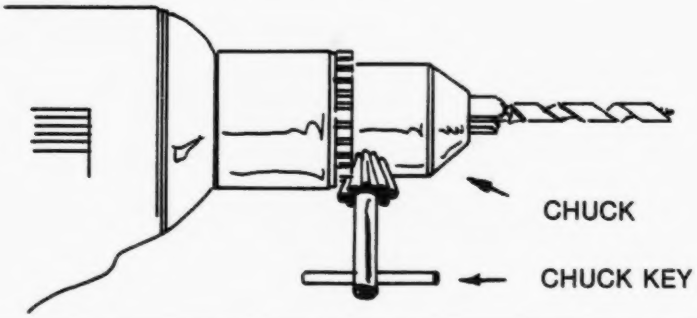
B. Drills are important in auto body work, especially for drilling out the spot welds which hold many panels together.

C. Electric drills use an electric motor to drive a chuck, which is a device which clamps down on drill bits of various sizes. Pneumatic tools use a rotor, which drives the chuck.

D. A chuck key is used to loosen and tighten the chuck, securing the drill bit in place.

E. The chuck holds the drill bit in place and aligns it properly. (FIG. 1-2)

FIGURE 1-2

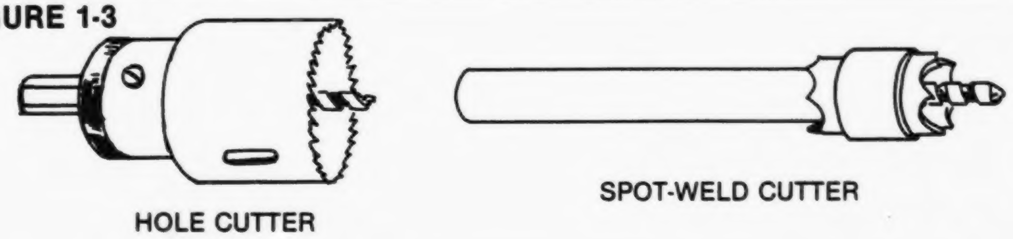


F. The size of the drill is the maximum diameter of the drill bit shaft that they will hold. The most popular sizes are 1/4 inch, 3/8 inch and 1/2 inch.

G. Drill bits

1. Drill bits come in various sizes and lengths and are interchangeable between electric and pneumatic drills.
2. Drill bits are composed of high-grade steel and if used properly they seldom need sharpening.
3. Drill bits are sized according to the size of hole they drill.
4. Some special drill bits are used in auto body work. (FIG. 1-3)

FIGURE 1-3



a. A hole cutter is a drill bit surrounded by a saw (hole cutter). The drill bit goes into the metal first, centering the hole cutter, and the hole cutter cuts a hole in the sheet metal.

b. A spot-weld cutter is much like a hole cutter, only it is much smaller and much stronger, allowing it to cut through welds.

H. Drill safety

1. Keep a firm grip on the drill and be ready to shut it off if it jams. Drills often jam just as they are about to penetrate what they are cutting.

2. If an electric drill jams, turn the drill off and pull it back out, then start it and continue to drill through the hole. The same procedure should be followed for re-starting a pneumatic drill.

   (NOTE: Such jamming may harm an electric drill.)

I. Drill bit size

1. When looking for a particular size of drill bit, use a drill gauge.

2. Do not use metric drills in place of USCS drills or vice-versa. If a 12 millimeter hole is required, then use a 12 millimeter bit.

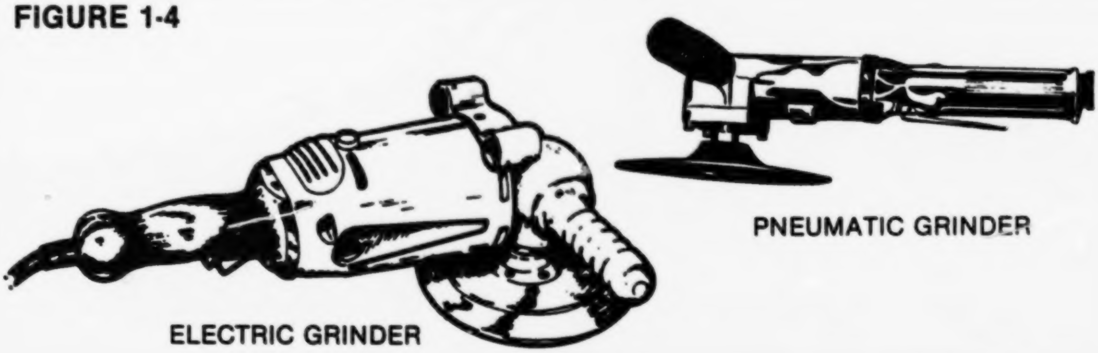
III. Sanders and polishers

A. Electric sanders may be used in many auto body operations, although pneumatic sanders are often preferred because they are lighter (a pneumatic rotary drive is far lighter than an electric motor).

B. There are four basic types of sanders

1. Rotary sanders (grinders) (FIG. 1-4)

FIGURE 1-4



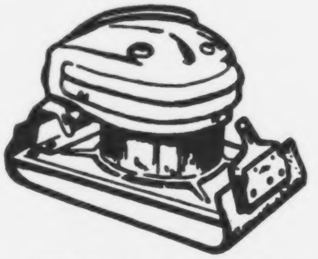
a. Use a disc that rotates in a circular motion

b. Used as a first step in smoothing a panel or to remove paint from a large area of a panel

c. Causes deep scratches that must be removed by using a different sander, or by hand-sanding

2. Reciprocating sanders (FIG. 1-5)

FIGURE 1-5



RECIPROCATING SANDER

a. The sander uses a square of abrasive which is moved back-and-forth in a straight line motion.

b. The sander is used to smooth metal or to smooth body filler.

c. A reciprocating sander is not usually used to featheredge and final sand. (See Module 4 "Paint and Refinishing.")

3. Orbital sanders

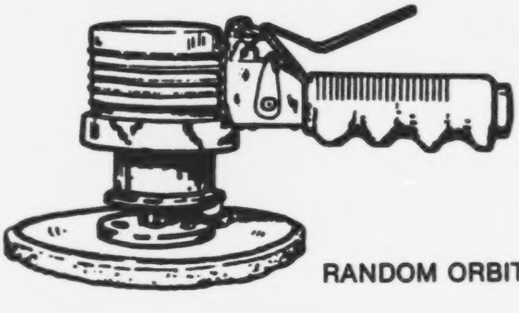
a. Some are of the same basic design as reciprocating sander, except that the abrasive is moved in an oval or circular motion. The circular motion is off-centered and is not the type of circular motion of the rotary sander.

b. Orbital sanders are used to featheredge and final sand repaired panels prior to refinishing.

c. Some orbital sanders are orbital-reciprocating sanders, meaning they have a switch that can be set for a reciprocating motion or an orbital motion.

d. One popular pneumatic sander is the random orbital sander which has a high-speed motion in which the sanding disk rotates while turning about a larger circle. (FIG. 1-6)

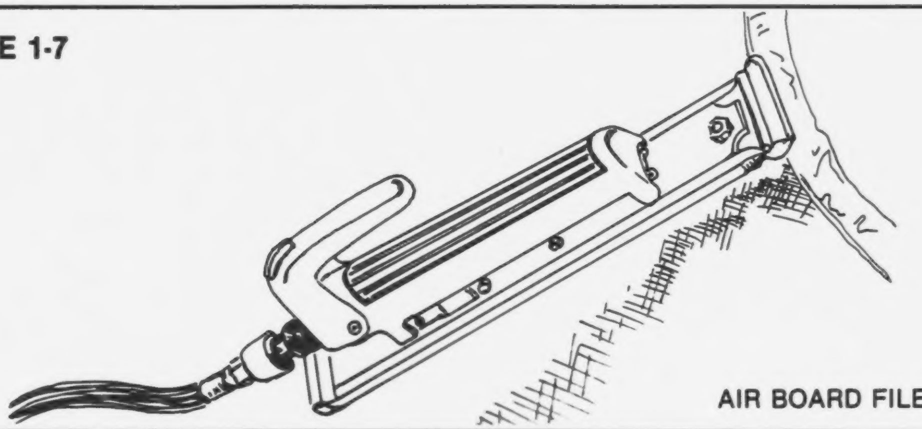
FIGURE 1-6



RANDOM ORBITAL SANDER

4. Air board file (FIG. 1-7)

FIGURE 1-7

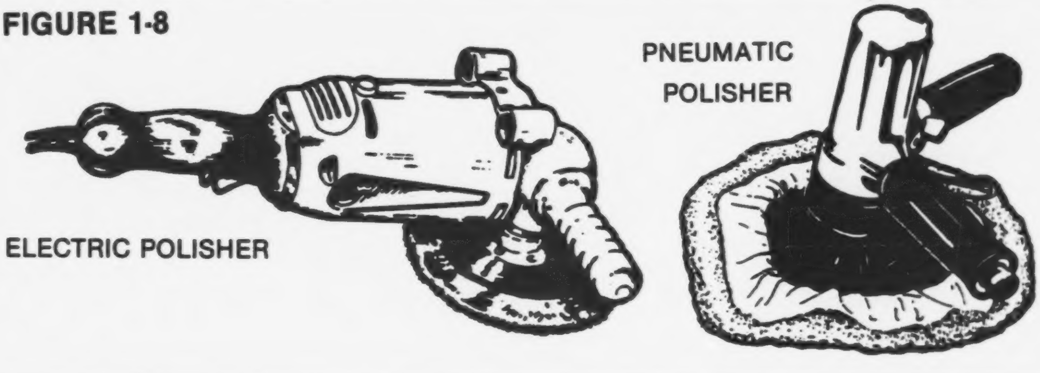


a. An air board file (air file) uses air from an air compressor to drive a long, reciprocating surface in a straight-line back-and-forth motion.

b. The air board file is another type of reciprocating sander and has the same basic effect, but can be used on a larger area.

C. Power polishers (FIG. 1-8)

FIGURE 1-8



1. A power polisher is the same basic tool as a rotary sander, except it operates at a higher speed (more revolutions per minute).

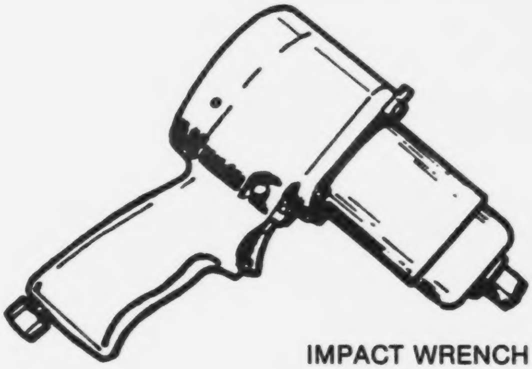
2. Some power sanders have a switch which changes their speed. By putting them on the higher setting and attaching a buffing pad, they become a power polisher.

3. The polishing pad is made of wool and is used after the application of rubbing compound or wax to bring out a high luster.

IV. Power wrenches and cutters

A. Impact wrenches (FIG. 1-9)

FIGURE 1-9



IMPACT WRENCH

2. The sockets used with impact wrenches are specially-made sockets of greater strength than standard sockets.

3. Both air and electric impact wrenches use a pounding motion to turn the socket, making it a very powerful tool.

4. A switch can change the impact wrench from counter-clockwise to clockwise operation.

5. Using impact wrenches

    a. Do not use standard sockets, which can be damaged or broken if used with an impact wrench.

    b. Use the correct socket.

    c. Use a deep socket where possible.

    d. Hold the wrench with a slight forward pressure on the bolt of nut.

    e. Use the simplest possible assembly of extensions and universal joints.

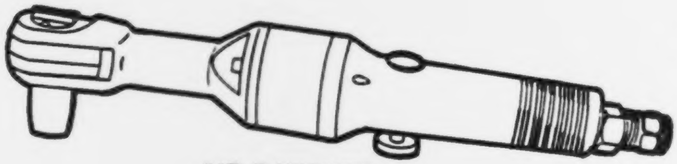
    f. Do not tighten a bolt or nut beyond one-half turn after it is tight.

    g. Soak rusty bolts of nuts with penetrating oil before using an impact wrench to loosen them.

    h. Do not use an impact wrench when a specific torque is required and do not use an impact wrench on small bolts and nuts.

B. Air ratchet (FIG. 1-10)

FIGURE 1-10

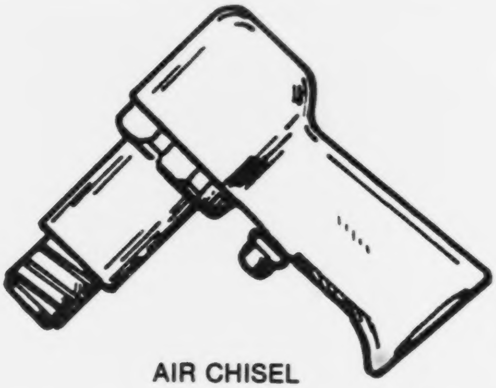


AIR RATCHET

1. An air rachet is smaller version of the impact wrench.
2. It delivers less force than the impact wrench and standard sockets may be used with it.
3. A switch can change it from clockwise to counterclockwise rotation.

C. Air chisel (air hammer) (FIG. 1-11)

FIGURE 1-11

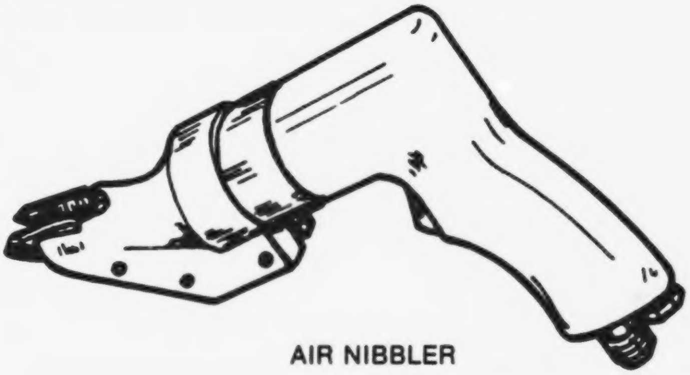


AIR CHISEL

1. Uses reciprocating motion to provide rapid impact force, much like a rapid series of short hammer blows
2. Different attachments are available, including cutters, chisels and punches
3. Often used to break welds loose

D. Air nibbler (FIG. 1-12)

FIGURE 1-12



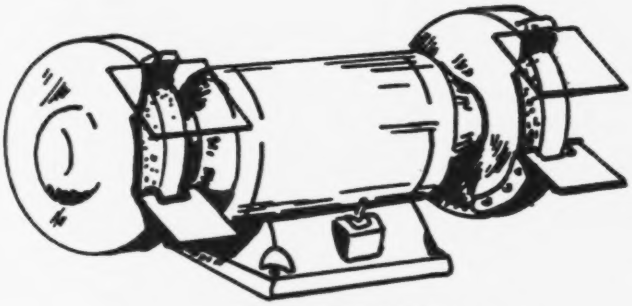
AIR NIBBLER

1. The air nibbler is much like powered metal snips.
2. The nibbler uses a movable center cutting blade which moves powerfully back and forth between two stationary cutting blades.
3. The nibbler is often used to make an accurate cut in replacing or sectioning cosmetic body panels.

V. Miscellaneous power tools

A. Electric bench grinder (FIG. 1-13)

FIGURE 1-13



BENCH GRINDER

1. A bench grinder is generally used to maintain tools which have become dull.
2. The grinder is mounted to a bench and is powered by an electric motor.
3. There are different grinding wheels that attach to the bench grinder.

4. Types of grinding wheels
    a. Different grits of grinding wheels, from fine to very coarse
    b. A wire brush wheel
5. Safety in using a bench grinder
    a. Follow bench grinder manufacturer's recommendations for removing and replacing grinding wheels. Do not over-tighten spindle nut.
    b. Bench grinder should have a work rest platform in front of each abrasive wheel, in addition to a wheel guard and an eye shield.
    c. Do not put excessive pressure on the wheel -- it could break apart.
    d. Beware of the damages of sparks to clothing, hair, or other flammable materials in the area.
    e. Always wear safety glasses and heavy gloves when working with a bench grinder.

B. Paint shakers
1. Most shops will have an electric or pneumatic paint shaker for agitating cans of paint.

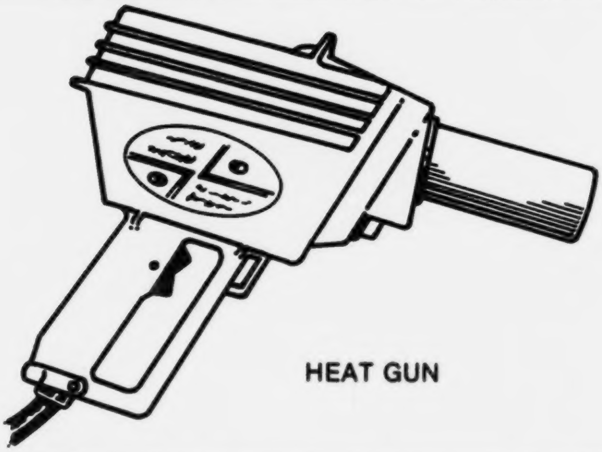
    (NOTE: Due to the danger of a spark or fire, a pneumatic shaker is preferred.)

2. The shaker has an electric motor and an eccentric motion, which shakes the paint can in multiple directions.
3. When using a paint shaker, be sure the paint can is in the shaker securely and be sure the paint can lid is secure.

C. Portable heat lamps
1. Heat lamps are used to dry paint.
2. Heat lamps are placed in stands and use infrared lamps.
3. Small heat lamps are called spot repair heat lamps and large heat lamps are called panel repair heat lamps.

D. Heat guns (FIG. 1-14)

FIGURE 1-14



1. Heat guns are hand-held heat generators which use forced air passing through heated coils.

2. Heat guns are used to soften or cure adhesives on vinyl tops, trim and decals.

E. Plastic welders

1. Hot air plastic welders

   a. Are similar to heat guns, but use a smaller stream of electrically-heated air to melt plastic materials

   b. See Module 3 "Panel Repairs" for use and maintenance of plastic welders.

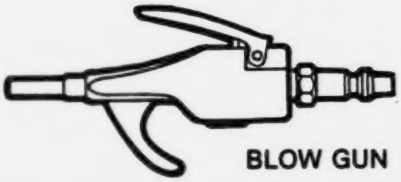
2. Airless plastic welders

   a. Use an electrically-heated tip to melt plastic welding rods

   b. See Module 3 "Panel Repairs" for use and maintenance of plastic welders.

F. Blow gun (FIG. 1-15)

FIGURE 1-15



1. The blow gun is a pneumatic attachment which directs a small, powerful stream of air.

2. The blow gun is used to clean dust from surfaces to be painted and is also used to clean dust from shop equipment.

   (CAUTION: *Only blow guns which have an approved pressure limiter should be used in the shop. A proper blow gun attachment limits the maximum pressure to 30 psi.)*

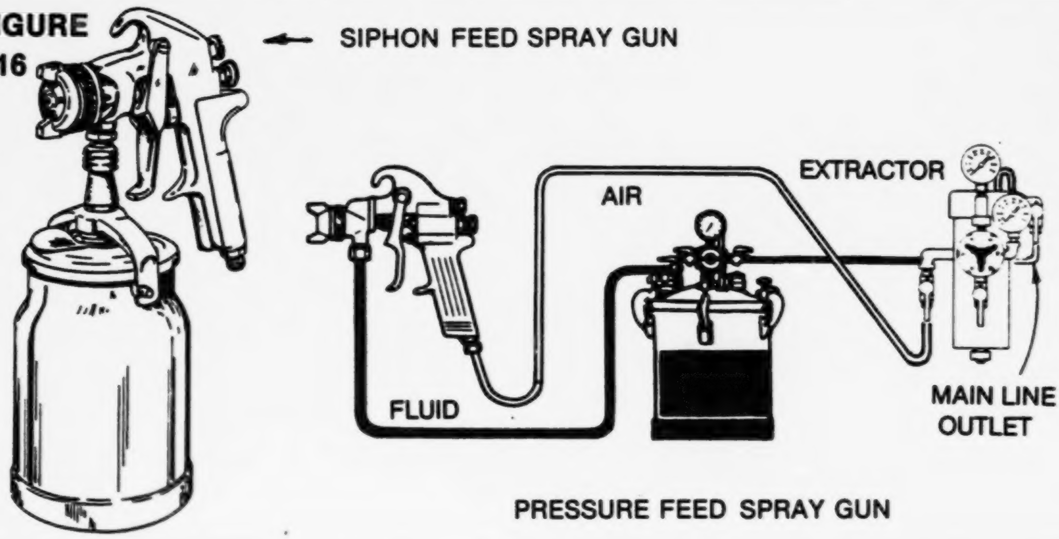
G. Paint spraying equipment

1. The siphon-feed spray gun (FIG. 1-16)
   - a. Compressed air going through gun causes a vacuum that pulls up the paint from the paint cup
   - b. Used in most spraying jobs, especially small jobs

2. The pressure-feed spray gun (FIG. 1-16)
   - a. Compressed air pressurizes a tank of paint and the paint is forced through the spray gun, along with a separate stream of compressed air

3. See Module 4 "Paint and Refinishing" for a detailed look at paint spraying equipment.

FIGURE 1-16



← SIPHON FEED SPRAY GUN

PRESSURE FEED SPRAY GUN

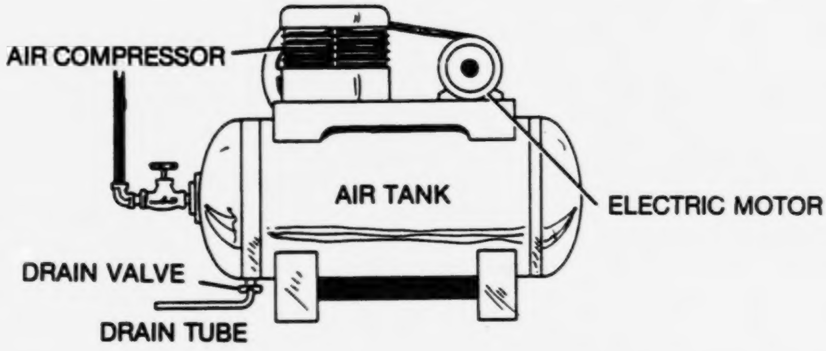
MODULE: INTRODUCTION TO AUTO BODY

UNIT IV: POWER TOOLS

LESSON TWO: PNEUMATIC AND HYDRAULIC EQUIPMENT

I. **Air compressor (FIG. 2-1)**

FIGURE 2-1



A. In order to operate spray painting equipment and pneumatic hand tools and equipment, the average body shop needs a large supply of compressed air.

B. All body shops will have one or more compressors.

C. Compressors are usually operated by an electric motor and are composed of three main parts.

   1. The motor

   2. The compressor

   3. The storage tank

D. The motor drives a compressor which takes in the air around it, compresses it into a smaller volume (thus increasing pressure) and then stores the compressed air in a large storage tank.

E. There are two types of compressors.

   1. One-stage compressors – The air is compressed once and then stored in the tank.

   2. Two-stage compressor – The air is compressed once, then moved into another part of the compressor and compressed again before being stored in the tank.

F. The operation of the compressor is much like a piston engine in reverse. In a piston engine, an explosion of gases causes the gases to expand, forcing the piston down. In a compressor, the piston is forced upward, compressing the air into a smaller and smaller area. When the piston reaches its highest point, a valve opens and the air is allowed to escape from the cylinder. It either escapes into the storage tank or escapes into another cylinder which further compresses it.

G. Each time the small amount of highly compressed air is allowed into the storage tank, it increases the pressure in the storage tank by a small amount. The pressure in the tank is allowed to rise until it reaches a level where it can provide the air needed for the body shop operation, while at the same time staying within the holding capability of the storage tank.

H. The air compressor is controlled by a regulator switch which operates off of the air pressure in the tank. The switch is set so that the compressor switches on when the pressure in the tank drops below a certain level and then switches off once the pressure has risen above a certain level.

I. A very important aspect of air compressors is that they provide a supply of *clean, moisture-free air*.

J. To provide clean air, the air is taken in through a filter.

K. To provide moisture-free air, the compressor and air distribution system take advantage of the fact that as air is compressed, it heats up (which is why compressors have cooling fins on them). When the hot compressed air goes into the storage tank it cools and moisture in the air condenses and falls to the bottom of the storage tank. A drain valve on the bottom of the storage tank is opened to drain away the water. The valve should be opened once each day.

L. To assist in providing moisture-free air, the distribution line coming from the tank is attached near the top of the tank. Any additional distribution lines coming off of main lines are usually attached at the top of the main line. Also the main line usually has a drain leg, a length of pipe which curves downward to a drain valve, providing another drain for moisture.

M. In addition to the drain valves, the air lines coming from the main line will all have their own regulator-separator.

   1. The regulator-separator serves a two-fold purpose of regulating the air pressure (reducing it to the amount needed to perform the work at hand) and also further cleaning the air of impurities.

   2. As air enters the cylindrical regulator separator, it is first directed downward, around the outside of an inner cylinder. It then moves upward through an opening at the bottom of the inner cylinder and passes around several baffles. The baffles throw the air against the side of the inner cylinder and the moisture "falls out" of the air and drops to the bottom of the regulator-separator, where it can be drained through a drain valve.

   3. After the air passes through the baffles it passes through a rock-wool filter which cleans remaining moisture, dirt and oil from the air.

   4. After passing through the separator portion, the air then enters the regulator portion, where a diaphragm valve regulates the amount of air flow.

5. A gauge on the regulator portion shows the amount of air pressure coming out of the unit.

N. Air hoses are constructed of special material designed to withstand the high pressure.

  1. Air hoses should not be run over with vehicles or equipment.
  2. Air hoses should not be used to pull tools across the shop floor.
  3. Air hoses should be neatly coiled for storage at the end of the working day.

O. Air compressor maintenance

  1. Check oil each week and maintain oil at proper level.
  2. Change oil every two months.
  3. Check belt condition and tension each week. Replace or adjust as needed.
  4. Clean air-intake breather each week.
  5. Drain water from tank and check air-safety valve each day.

II. Hydraulic equipment

A. In addition to electric and pneumatic equipment, a third variety of equipment is hydraulic.

B. Hydraulic equipment may use mechanical force, an electric motor, or compressed air as the source of power for the equipment. Hydraulic equipment which is powered by air is commonly referred to as "air-over-hydraulic" equipment.

C. The power source drives a hydraulic pump which multiplies the input force.

(NOTE: Hydraulic equipment multiplies input force at the sacrifice of speed. The greater the amount of force desired from a piece of hydraulic equipment, the slower the equipment will work. For example, it would take twice as long to jack up a vehicle with a hydraulic pump that multiplied force six times, as it would with a hydraulic pump that multiplied force three times. However, you could lift a vehicle twice as heavy with a hydraulic pump that multiplied force six times.)

D. Hydraulic equipment uses hydraulic fluid -- a petroleum product, much like oil.

E. Hydraulic equipment should be checked frequently for leaks. Leaks can cause the hydraulic equipment to fail, with dangerous results.

F. Hydraulic equipment is used for situations which require a large amount of force, and in situations which require that the force be maintained constantly.

EXAMPLE: The hydraulic jack not only raises a heavy vehicle into the air, but it also holds the vehicle in the air.

G. The two main applications of hydraulic equipment

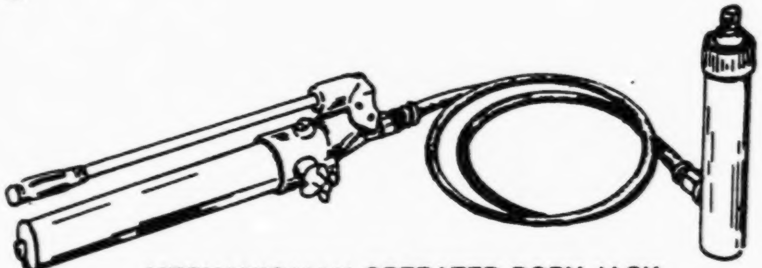
1. Lifting vehicles
2. Straightening damaged vehicle components

H. Engine hoist

1. Another type of hydraulic jack is the engine hoist, or portable crane on wheels, which also uses mechanical force.
2. The engine hoist is simply a hydraulic jack which is designed for attaching onto the top of an object and pulling it upward, instead of getting underneath of an object and pushing it upward.
3. An engine hoist is commonly used to lift the engine out of a vehicle, but can find many other applications for transporting heavy objects short distances around the shop.
4. Safety
    a. Stand clear of any object being raised in case the hoist fails or topples, or the object being lifted comes loose.
    b. When moving an object that is suspended from the crane, move the crane very slowly.
    c. Do not work on any object while it is suspended from the crane – lower it to a workbench or the floor (or into a motor stand for a motor).

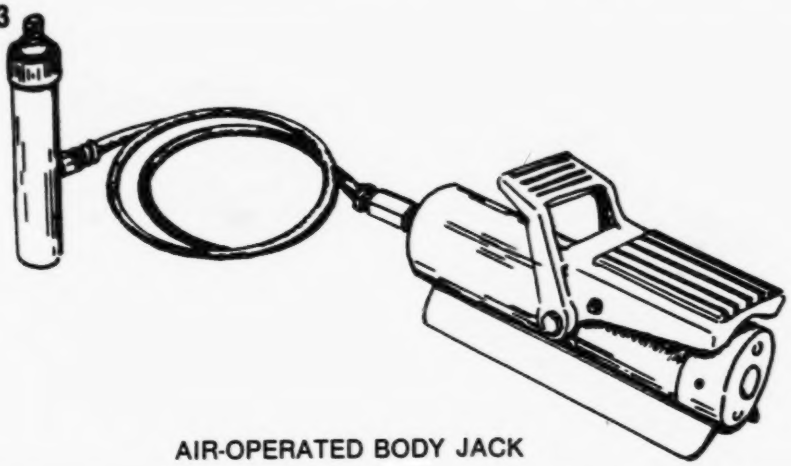
III. **Hydraulic body jacks (FIG. 2-2, FIG. 2-3)**

FIGURE 2-2



MECHANICALLY OPERATED BODY JACK

FIGURE 2-3



AIR-OPERATED BODY JACK

A. Hydraulic body jacks are among the most useful items in the body shop.

B. They are designed for straightening damaged body panels.

C. Hydraulic body jacks are used in situations of light-to-moderate damage to panels, where the damage is too great to be fixed with hand tools.

D. Hydraulic body jacks are used in the following situations

   1. When one panel can be straightened by grabbing opposite ends of the panel and pulling or pushing

   2. Where a panel can be straightened by pushing or pulling against an adjacent panel

E. Great care must be taken in using hydraulic body jacks

   1. There is tremendous force in these tools, which must be respected at all times.

   2. When pushing body panels apart or pulling them together, great care must be taken that undamaged panels are not damaged.

      (NOTE: It is better to use frame-straightening equipment to straighten damaged panels in many situations. Frame straightening equipment can be set up in such a way that only the damaged panel will receive any force. Although hydraulic body jacks take less time to set up than frame-straightening equipment, they can cause damage to the vehicle if not used properly.)

F. The parts of the hydraulic body jack

   1. There are three basic parts

  a. The pump

  b. The ram

  c. The hose

2. The pump is the power source for the body jack and in most cases is also the reservoir for hydraulic fluid. The pump may be operated manually, by a lever, or with compressed air. As with a hydraulic floor jack, there is a fluid release valve which must be tightened to engage the pressure and loosened to release the pressure.

3. The ram is the part of the jack which does the actual work. The pump is connected to the ram via the hose. The ram is basically a piston inside of a cylinder. As pressure is applied, the piston moves outward. Rams come in various designs to direct the ram's force in different ways.

   (NOTE: They may be designed in such a way that they pull or push. Rams of different lengths are available, depending on how much travel will be needed for the straightening operation, how far apart the ends of the ram need to be, and how much space is available for the operation.)

4. The hose is a specially designed hose with threaded attachments at each end. One end attaches to the pump and the other end to the ram.

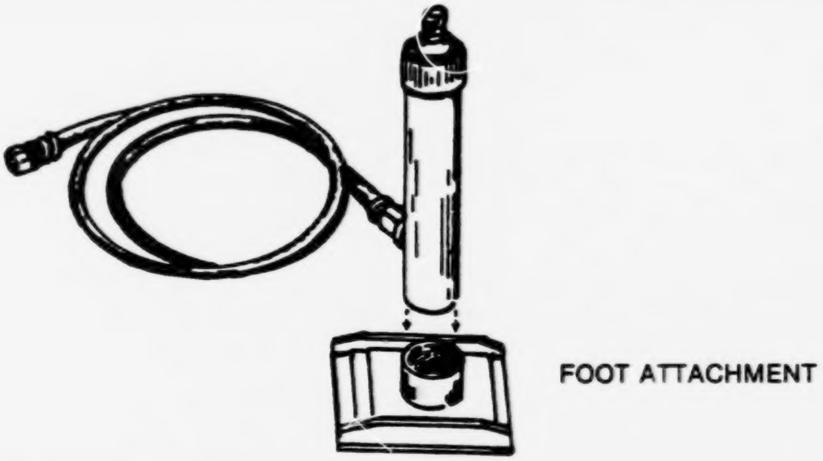
5. Various types of attachments are available for the hydraulic body jack.

   a. Clamps and chains for pulling operations

   b. Hooks for pulling operations

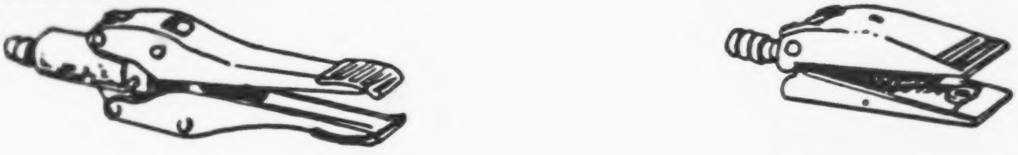
   c. "Foot" attachments for pushing operations (FIG. 2-4)

FIGURE 2-4



d. Spreader attachments for spreading apart panels which have been crushed together. (FIG. 2-5)

FIGURE 2-5



SPREAD RAM

WEDGE RAM

(NOTE: Hydraulic rams are also used in frame-straightening systems. See Module 7 "Frame-Body and Unibody Construction and Repair" for a detailed discussion of frame-straightening systems.)

G. Maintenance

1. Rams come in various capacities, measured in tons of force. This capacity must not be exceeded.
2. Misuse of the ram could result in damage to the ram or to the vehicle.
3. The ram must not be overextended. Because of the tremendous force, the ram can push the piston completely out of the top of the ram.
4. Keep the hose free from kinks and do not drop heavy objects onto the hose.
5. Keep heat away from the pump, the ram and the hose.
6. Before use, check the condition of the hose and the ram. On the ram, check for leaks around the seals and for bent components.
7. Use only clean hydraulic fluid of the recommended type in the pump.

H. Safety

1. Make sure the ram is properly secured when pulling or pushing.
2. Make sure any extensions or attachments are connected properly and the threads are not damaged.
3. When operating a body jack, stay as far away from the jack as possible and do not stand in the direct line of the pressure being applied.
4. If using chain attachments, wrap the chains or bolt on a safety chain if the chain is long enough that it could damage an undamaged area of the vehicle if it snaps, or if it could injure the operator if it snaps.

5. Always wear safety glasses when operating hydraulic body jacks. The pressure of the ram may cause vehicle parts to break and fly off with enough force to put out an eye.

6. If using body jacks in an area where vehicle glass is present, either remove the glass or tape the glass so that if it breaks, the glass will not fly through the air.

IV. Frame-straightening equipment

(NOTE: Most frame-straightening equipment is hydraulically operated, but the hydraulic pumps are, in turn, operated by compressed air.)

A. Frame-straightening equipment is hydraulically operated.

B. Frame-straightening equipment differs from portable body jacks in that the frame-straightening equipment is designed to anchor the vehicle in a stationary position so that force can be applied directly to a panel in any direction needed.

C. Frame-straightening equipment is more powerful than hydraulic body jacks and is used to straighten major damage to vehicle panels, including structural components or frames.

D. Types of frame-straightening units

(NOTE: The following are basic designs, with many variations. A more detailed discussion is presented in Module 7 "Frame-Body and Unibody Construction and Repair" on how frame-straightening units are combined with measuring systems.)

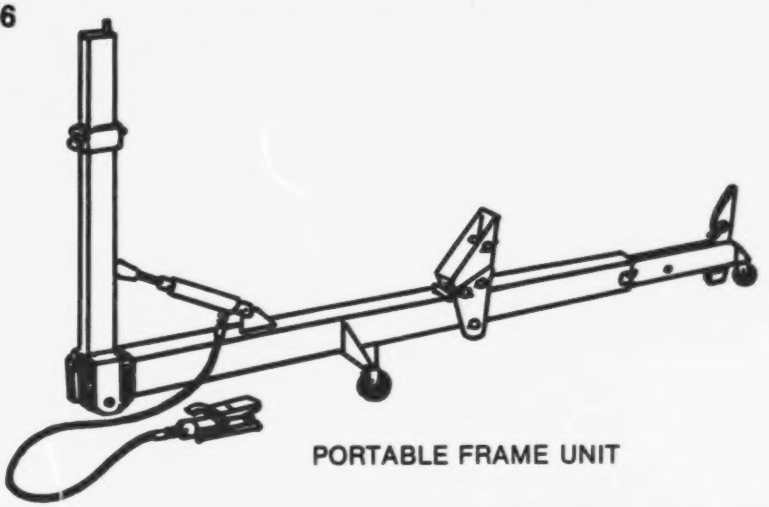
1. Portable frame unit (Also known as the damage dozer)
2. Stationary rack
3. Floor anchor (pots or slotted rails)

E. The components of modern pulling systems

1. An anchoring system
2. Clamps, hooks, attachments and chains
3. Hydraulic pulling equipment

F. Portable frame unit (damage dozer) (FIG. 2-6)

FIGURE 2-6

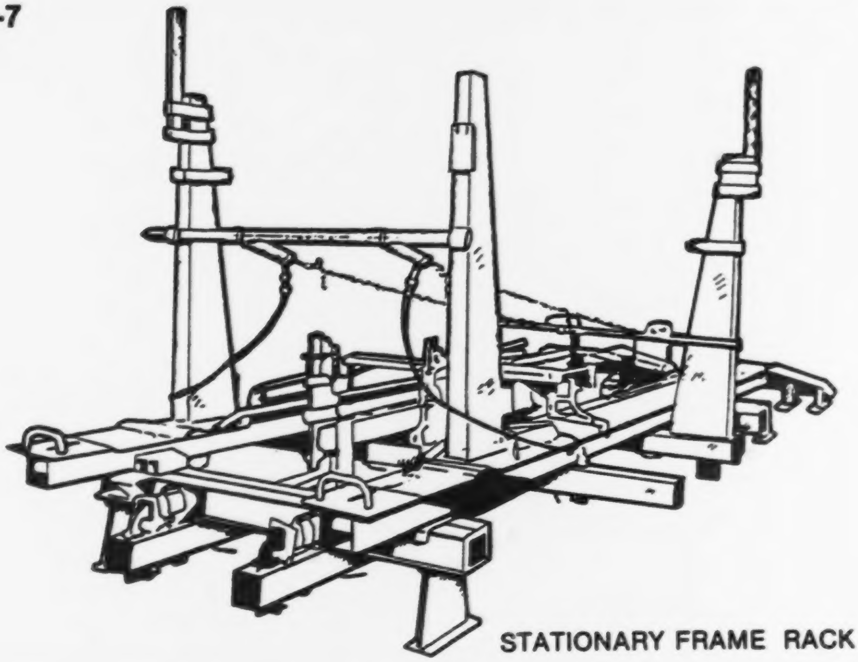


PORTABLE FRAME UNIT

1. Provides single-direction pull or push
2. Is mounted on wheels and can be moved easily; safety stands or other system must support vehicle
3. Anchors itself to vehicle, but does not actually anchor the vehicle (It pulls against a strong portion of the vehicle.)
4. Uses a hydraulic ram for pulling power

G. Stationary frame rack (FIG. 2-7)

FIGURE 2-7

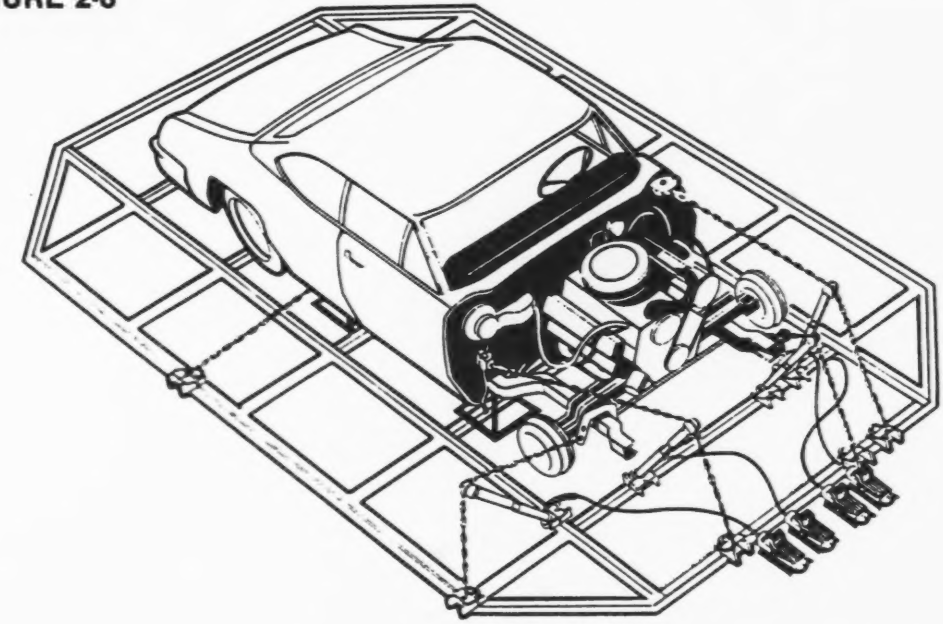


STATIONARY FRAME RACK

1. Provides pulls in different directions at the same time
2. Is usually bolted onto, or built into floor of shop; vehicle can be pulled or driven onto rack
3. Anchors vehicle to the rack
4. Uses hydraulic rams and/or hydraulic jacks

H. Floor anchor (FIG. 2-8)

FIGURE 2-8



FLOOR ANCHOR

1. Provides multiple pulls or pushes

2. Is installed into floor, with either pot hole anchors or an anchoring grid; car must be lifted onto stands

3. Provides multiple anchoring and pulling points

4. Is used together with air-over-hydraulic rams, and occasionally hydraulic jacks

I. Vehicle anchoring equipment

1. Frame stands

   a. Are stronger than safety stands and are used whenever frame-straightening equipment is being used

   b. The vehicle is placed onto the stands and then vehicle is anchored by a floor-anchoring system.

   c. Four frame stands will be used, one at each of the four torque box areas (See Unit V, this module)

2. Suspension stands

   a. Are attached to the lug bolts of the vehicle wheels, after removal of the tires

   b. Are used with frame-straightening equipment when it is desired to have the vehicle resting on the suspension

3. Frame clamp

   a. Is used on unibody vehicles

   b. Attaches to the pinchwelds on the rocker panels in each of the four torque box areas

4. Dedicated or universal benches

   a. Anchor the vehicle at the four torque box areas with various clamps

   b. Allow vehicle to be moved around shop on bench

   c. Provide attachment points for measuring systems

   (NOTE: See Module 7 "Frame-Body and Unibody Construction and Repair" for a thorough discussion of dedicated and universal benches, as well as a discussion of safety practices.)

MODULE: INTRODUCTION TO AUTO BODY

UNIT IV: POWER TOOLS AND EQUIPMENT

UNIT IV TEST

PART I--GENERAL PRINCIPLES OF ELECTRIC AND PNEUMATIC HAND TOOLS

I. Mark a T on the test or the answer sheet if the statement is true and an F if the statement is false.

_____1. You should not use electrical equipment with damaged cords.

_____2. You should use electrical equipment that does not have a grounded plug.

_____3. Some electrical equipment must be oiled occasionally.

_____4. Pneumatic tools are heavier than electric tools but they work faster.

_____5. Pneumatic tools are not damaged by overloading or stalling.

_____6. Before an air tool is used, flushing oil should be applied to the air inlet.

_____7. You should not operate any piece of equipment unless you have been instructed in the use of the equipment.

_____8. As soon as you lay a disk grinder on the floor or another surface, it will completely stop turning.

_____9. If you are using a disc grinder or oxyacetylene torch near the fuel filler opening or fuel tank, you should always remove the fuel tank first.

_____10. Do not operate air chisels without a chisel in them.

_____11. When changing attachments or servicing pneumatic tools, you should always disconnect them from the air supply first.

_____12. When working near anything with a rotating part, such as a grinder, you should stand in the plane of the rotating part.

_____13. Electrical cords should not be run through holes in the wall.

PART II--ELECTRIC AND PNEUMATIC HAND TOOLS

I. Mark a T on the test or the answer sheet if the statement is true and an F if the statement is false.

_____14. Electric drills can be used interchangeably with pneumatic drills.

_____15. Drill bits are sized according to the size of hole they drill.

_____16. A power polisher is turns at a slower speed than a rotary sander.

_____17. Sockets used with impact wrenches are specially made sockets of greater strength than standard sockets.

_____18. You should not tighten a bolt with an impact wrench beyond one-half turn after it is tight.

_____19. An air nibbler is often used to break loose welds.

II. Match the tool in the right column with the description in the left column.

_____20. Electric motor drives the chuck

_____21. Pneumatic rotor drives the chuck

_____22. Rotates in a circular motion, used as a first step in smoothing a panel

_____23. Any sander which moves back and forth in a straight line, used to smooth metal and smooth body filler

_____24. Moves in an off-centered, circular motion, used to featheredge

_____25. Pneumatic reciprocating sander

_____26. Has high-speed rotary motion, uses buffing pad

_____27. Uses pounding motion to turn a socket with great force

_____28. Pneumatic socket drive which uses standard sockets

_____29. Uses pounding motion to deliver hammering force

_____30. Air-powered metal snips

_____31. Directs a stream of compressed air

A. Air file

B. Reciprocating sander

C. Speed socket

D. Power polisher

E. Air Nibbler

AB. Air ratchet

AC. Electric drill

AD. Random orbital sander

AE. Impact wrench

BC. Blow gun

BD. Rotary sander

BE. Air chisel

CD. Pneumatic drill

III. Match the name of the tool in the left column with the correct illustration.

_____32. Electric drill

_____33. Pneumatic drill

_____34. Rotary sander

_____35. Reciprocating sander

_____36. Random orbital sander

_____37. Air file

_____38. Power polisher

_____39. Impact wrench

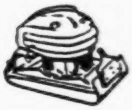
_____40. Air rachet

_____41. Air chisel

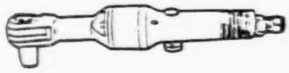
_____42. Air nibbler

_____43. Blow gun

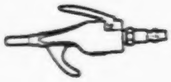
A.



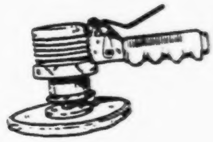
B.



C.



D.



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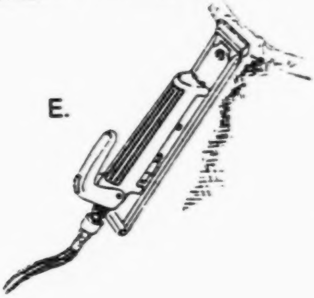
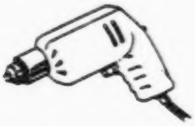


AB.



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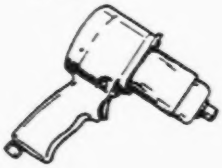
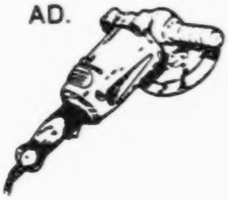
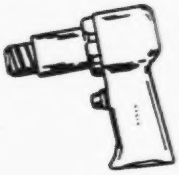


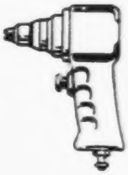
AD.



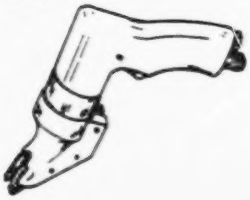
AE.



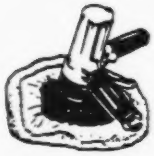
BC.



BD.



BE.



(NOTE: Completion of this portion of the unit test is the evaluation for Compentency C3 "Demonstrate safe use and maintenance of electric and pneumatic hand tools." Of the 43 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this portion of the test.)

PART III—ELECTRIC AND PNEUMATIC EQUIPMENT

I. Match the name of the tool in the left column with the correct illustration.

_____44. Siphon-feed spray gun

_____45. Pressure-feed spray gun

_____46. Bench grinder

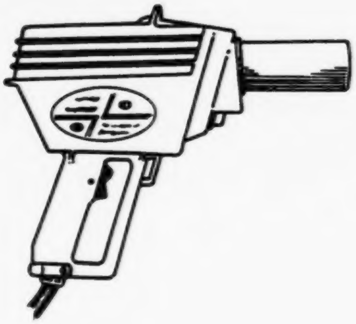
_____47. Heat gun

_____48. Air compressor

_____49. Ram

_____50. Spread ram

A.



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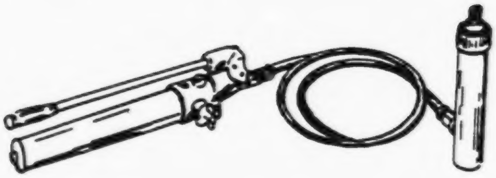
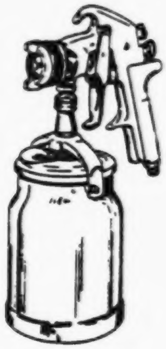


C.



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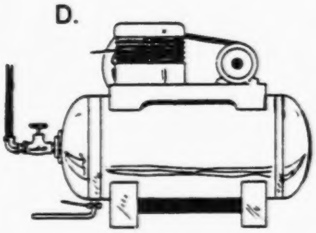
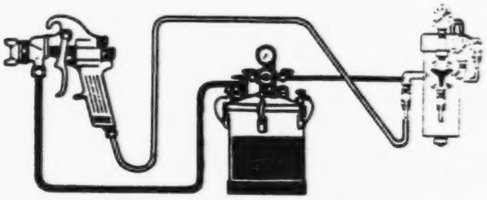


E.



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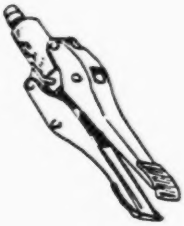
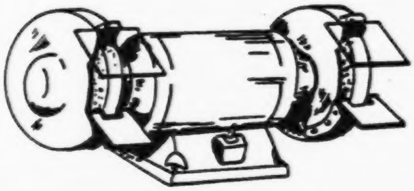
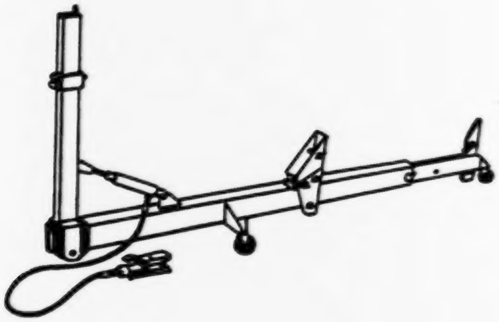


AC.

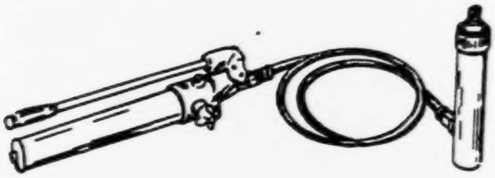


II. Select the best answer from the choices listed.

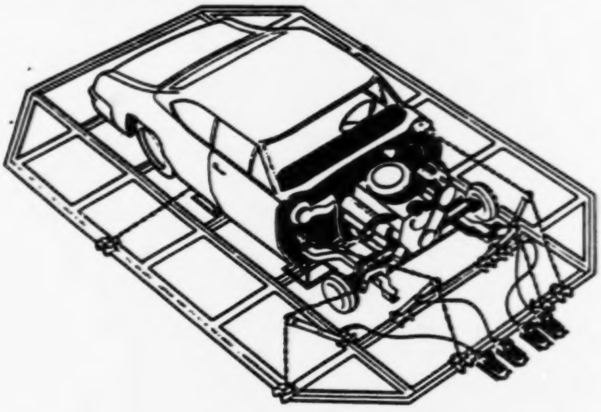
_____51. The type of equipment pictured below is: (a) a portable frame unit, (b) a floor anchor, (c) a stationary frame rack, (d) a mechanical body jack, (e) a pneumatic body jack.



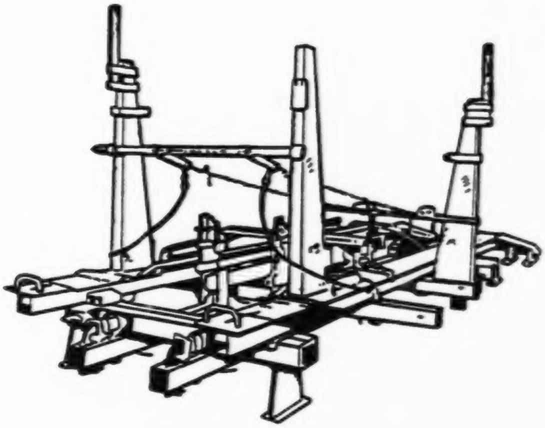
_____52. The type of equipment pictured below is: (a) a portable frame unit, (b) a floor anchor, (c) a stationary frame rack, (d) a mechanical body jack, (e) a pneumatic body jack.



_____53. The type of equipment pictured below is: (a) a portable frame unit, (b) a floor anchor, (c) a stationary frame rack, (d) a mechanical body jack, (e) a pneumatic body jack.



_____54. The type of equipment pictured below is: (a) a portable frame unit, (b) a floor anchor, (c) a stationary frame rack, (d) a mechanical body jack, (e) a pneumatic body jack.



III. Match the equipment in the right column with the description in the left column.

_____55. Uses vacuum to apply paint

_____56. Used to maintain tools

_____57. Has eccentric motion which shakes cans in multiple directions

_____58. Used to dry paint

_____59. Used to soften or cure adhesives

_____60. Uses a small stream of electrically-heated air to melt plastic

_____61. Uses electrically-heated tip to melt welding rods

_____62. Provides air for pneumatic equipment

_____63. Uses mechanical force of a lever to raise parts

_____64. Straightens panels in light-to-moderate damage where a single panel can be pulled or pushed by grabbing opposite ends, or where a push can be made against an adjacent panel

_____65. Can only make a one-direction pull

_____66. Anchors vehicle, provides several pulls at once and vehicle is driven onto it

_____67. Provides multiple pulls, and is installed into floor using either pots or slotted rails

A. Air compressor

B. Bench grinder

C. Hydraulic body jack

D. Heat gun

E. Stationary frame rack

AB. Siphon-feed spray gun

AC. Pneumatic floor jack

AD. Paint shaker

AE. Floor anchor

BC. Hot air welder

BD. Airless welder

BE. Portable heat lamp

CD. Damage Dozer

CE. Engine hoist

IV. Mark a T on the test or the answer sheet if the statement is true and an F if the statement is false.

_____68. Drain valves on air compressors and drain valves on air compressor lines should never be opened.

_____69. Hydraulic equipment uses hydraulic fluid.

_____70. Hydraulic equipment should be checked frequently for leaks.

_____71. The three basic parts of the hydraulic body jack are the pump, the ram and the hose.

_____72. When operating a body jack, you should not stand in a direct line with the pull.

_____73. When working with frame-straightening equipment, you should use safety stands under the vehicle.

_____74. When operating a body jack, you should stay as far away from the jack as possible and do not stand in a direct line of the pressure being applied.

_____75. You should not do any welding unless you are in a protective welding enclosure.

_____76. In using welding equipment you should never drag the cables or hoses of any type of welder through dirt or oil, and never pull on a cable to force it over an obstruction.

_____77. You should never use oxygen as a substitute for compressed air or as a source of pressure.

_____78. Never use a match to light an acetylene torch.

_____79. Dust can explode.

V. Select the best answer from the choices listed.

_____80. Which of the following is an item you should NOT wear when working around moving machinery or electrical equipment: (a) rings, (b) bracelets (c) watches (d) a and b, (e) a, b and c.

_____81. When using air for cleaning purposes the air must not be more than: (a) 15 psi, (b) 30 psi, (c) 45 psi, (d) 60 psi, (e) 75 psi.

_____82. If the floor is wet you must NOT use, (a) refinishing equipment, (b) sandpaper, (c) pneumatic equipment, (d) electrical equipment, (e) all of the above.

_____83. Which of the following safety features must be present on a bench grinder: (a) work rest platform, (b) wheel guard, (c) eye shield (d) a and b, (e) a, b and c.

_____84. Many welding activities produce toxic fumes and vapors that are hazardous to breathe. To prevent this from being a health hazard, you should: (a) work in an area with a proper ventilation or exhaust system, (b) move your head to the side of rising fumes, (c) wear a filter-type respirator, (d) a and b, (e) a, b and c.

_____85. In using electric welders, the work area, the equipment and your clothing must be dry because even a slight amount of moisture can cause: (a) the equipment to fail, (b) the weld to fail, (c) your clothing to burn, (d) a welding rod to explode, (e) an electric shock.

_____86. A welding arc produces ultraviolet and infrared radiation that can harm your: (a) skin, (b) eyes, (c) clothes, (d) ears, (e) a and b.

_____87. Oxygen and acetylene cylinders should be stored: (a) in a small room, (b) in a concrete room, (c) together, (d) separately, 20 feet apart, (e) b and c.

_____88. An extremely hazardous situation with oxyacetylene welding is if oxygen under pressure is allowed to come into contact with: (a) hot metal, (b) oil or grease, (c) paint products, (d) acetylene, (e) argon.

_____89. You should never use acetylene at a pressure above: (a) 15 psi, (b) 25 psi, (c) 35 psi, (d) 50 psi, (e) 75 psi.

_____90. Gas cylinders have a protective cap which should be in place: (a) all the time, (b) anytime they are not hooked to the regulator, (c) anytime they are being transported, (d) anytime they are being stored, (e) all the time, unless they are empty.

(NOTE: Completion of this portion of the unit test is the evaluation for Competency C4 "Demonstrate safe use and maintenance of electric, pneumatic and hydraulic equipment." Of the 47 questions a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this portion of the test.)

ANSWERS TO UNIT IV TEST

PART I.

1. T
2. F
3. T
4. F
5. T
6. T
7. T
8. F
9. T
10. T
11. T
12. F
13. T

PART II.

14. T
15. T
16. T
17. T
18. T
19. F

20. AC
21. CD
22. BD
23. B
24. AD
25. A
26. D
27. AE
28. AB
29. BE
30. E
31. BC

32. AB
33. BC
34. AD
35. A
36. D
37. E
38. BE
39. AC
40. B
41. AE
42. BD
43. C

PART III.

44. C
45. E
46. AC
47. A
48. D
49. B
50. AB

51. A
52. D
53. B
54. C

55. AB
56. B
57. AD
58. BE
59. D
60. BC
61. BD
62. A
63. CE
64. C
65. CD
66. E
67. AE

68. F
69. T
70. T
71. T
72. T
73. F
74. T
75. T
76. T
77. T
78. T
79. T

80. E
81. B
82. D
83. E
84. D
85. E
86. E
87. D
88. B
89. A
90. B

MODULE: INTRODUCTION TO AUTO BODY

UNIT V: RAISING AND SUPPORTING VEHICLES

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify safe practices for raising and supporting vehicles and be able to describe how to safely raise specific vehicles in the shop. Mastery will be evidence by scoring ______ percent on the unit test and ______ percent on an assignment sheet, as well as by demonstrating safe practices whenever raising and supporting vehicles.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit the student should be able to:

Lesson 1:

I. Identify terms and definitions associated with lifting and supporting vehicles. (Competency C5, Part I, Unit V test)

II. Identify the safe use and maintenance of vehicle lifting equipment (Competency C5, Part II, Unit V test)

III. Identify jacking and supporting areas for vehicles. (Competency C5, Part III, Unit V test)

IV. Identify principles of lifting, jacking and supporting vehicles. (Competency C5, Part IV, Unit V test)

V. Describe proper lifting and jacking techniques (Competency C5, Assignment Sheet #1)

MODULE: INTRODUCTION TO AUTO BODY

UNIT V: RAISING AND SUPPORTING VEHICLES

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

  1. Lesson 1: Proper lifting and jacking techniques

    a. Information outline

    b. Assignment sheet #1: Identify proper lifting and jacking techniques.

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Due to the extreme safety considerations in lifting and supporting vehicles, the techniques in this unit should be thoroughly demonstrated to the students.

B. In having students perform Assignment Sheet #1, at least one of the vehicles should be a unibody vehicle.

REFERENCES USED IN WRITING THIS UNIT

1. Blackhawk Automotive. *New Science of Unibody Repair.* Blackhawk Automotive. Milwaukee, WI. 1984.

2. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

3. Czapskie, George S., et. al. *Auto Body Repair.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1977.

4. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL. 1984.

5. Foutes, William. *Diesel Mechanics: Fundamentals.* Mid-America Vocational Curriculum Consortium, Inc. Stillwater, OK. 1982.

6. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.
7. Toboldt, Bill. *Auto Body Repairing and Repainting.* The Goodheart-Willcox Co. Inc. South Holland, IL 1982.

MODULE: INTRODUCTION TO AUTO BODY

UNIT V: PROPER LIFTING AND SUPPORTING OF VEHICLES

LESSON ONE: PROPER LIFTING, JACKING AND SUPPORTING METHODS

I. **Terms and definitions**

A. Frame stands – Specially built supports resembling safety stands. They are designed specifically for supporting vehicles during frame repair procedures.

(CAUTION: Frame stands are not the same as safety stands or jack stands. Safety stands may be used to support a vehicle for analysis, but not for repairs.)

B. Jacking – Raising a vehicle off the ground with a device that puts pressure only on one small area, such as a hydraulic floor jack.

C. Lifting – Raising a vehicle off the ground with a device that puts pressure on a large area or areas, such as a bumper-type end lift.

D. Pinchweld area of the rocker panel – The factory weld that fuses the bottom flange of the outer rocker panel to the inner rocker panel. It is the strongest point for lifting, supporting and anchoring unibody vehicles.

E. Supporting – Either using stands to hold the vehicle high enough to allow measuring systems to be employed, or using a bench to support the vehicle.

F. Support tubes – Strong steel tubes specially designed to be placed between two pinchweld clamps to provide lifting and supporting points. Also called cross tubes.

G. Torque boxes -- Energy management design often used in both conventional frames and unibody construction, in which each corner of the passenger compartment is made with a twist-absorbing design.

H. Torque box areas – Refer to the four corners of the passenger compartment regardless of whether the vehicle actually has torque boxes.

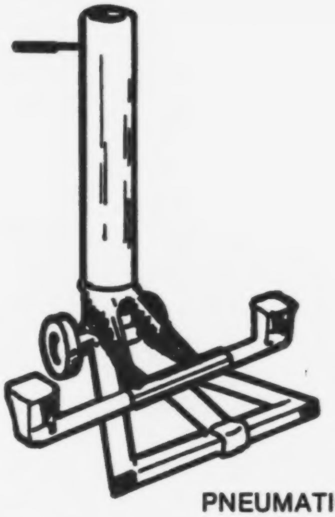
II. **Lifting devices**

A. In order to perform repairs on many damaged vehicles, it is necessary to get the vehicle off of the ground to provide access to the underside.

B. There is a wide variety of equipment available for lifting vehicles. Most equipment is hydraulic, but there are also pneumatic lifts.

C. Pneumatic floor jack (FIG. 1-1)

FIGURE 1-1



PNEUMATIC BUMPER-TYPE END LIFT

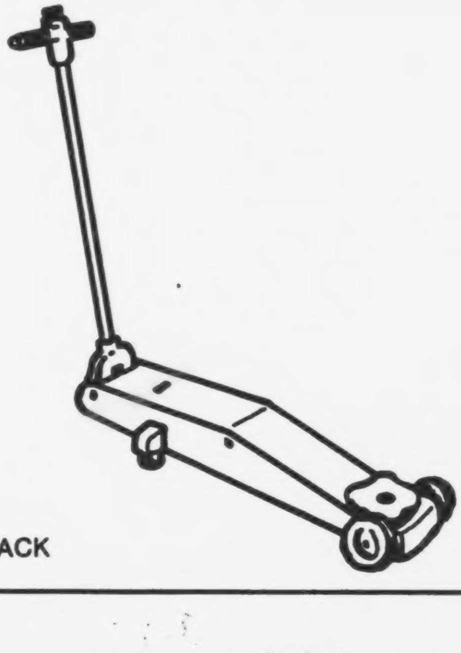
1. The most common type of pneumatic floor jack is the bumper-type end lift.

2. The bumper-type end lift lifts up one end of the vehicle at a time, usually raising the vehicle by the bumper.

   (CAUTION: *Some vehicles should not be raised with a bumper-type end lift. Consult vehicle service manual before using such a lift.)*

D. Hydraulic floor jacks (FIG. 1-2)

FIGURE 1-2



HYDRAULIC FLOOR JACK

1. Hydraulic floor jacks use mechanical force, with the operator using a lever to "pump up" the jack.

2. Hydraulic floor jacks are used often in raising a vehicle for placement on safety stands or frame stands.

3. Safety

   a. Always be sure the release valve is completely closed before using.

   b. NEVER crawl under a car held up only by a jack, either hydraulic or pneumatic. Use safety stands or frame stands.

   c. Make sure everyone in the vicinity is standing well away from a raised vehicle before you open the release valve to lower it. When lowering a vehicle the release mechanism should be opened a little at a time, and then closed, lowering the vehicle a little at a time.

      (NOTE: If the release mechanism is opened all the way, it will drop the vehicle to the floor instantly, possibly injuring the vehicle, yourself or others.)

   d. After raising a vehicle with a floor jack, be sure the handle of the jack is pointed straight up.

   e. Do not operate hydraulic lifts if they are leaking.

   f. Do not lift vehicles with passengers inside, or with doors, hood, or deck lid open.

III. Jacking and supporting areas for vehicles

A. Torque box areas (FIG. 1-3, page 100)

1. Are used in both frame-body and unitized designs

2. Are designed to absorb twist (torque) forces, making for smoother riding in frame-body vehicles

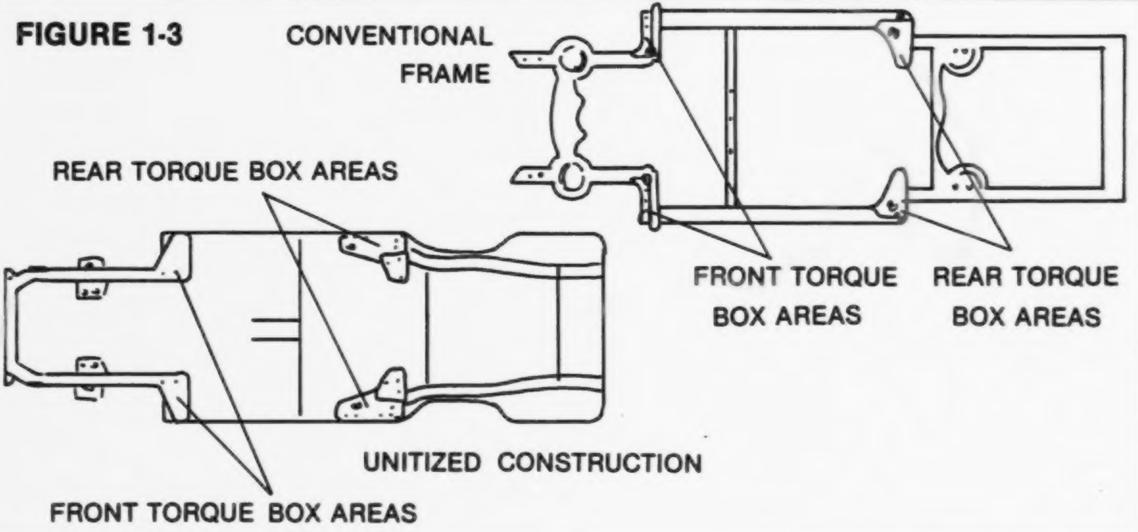
3. Are designed to absorb twisting forces in a collision, routing damage away from passenger compartment

4. There are always four torque box areas per vehicle, at the corners of the passenger section.

5. Even if the vehicle does not have actual torque boxes, the four corners of the passenger compartment are referred to as "torque box areas."

6. Torque box areas are generally the strongest areas of vehicle for lifting and supporting.

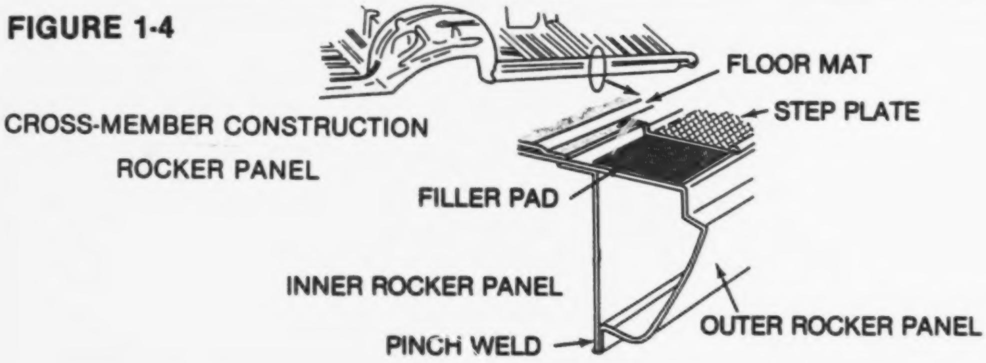
FIGURE 1-3


CONVENTIONAL FRAME
REAR TORQUE BOX AREAS
FRONT TORQUE BOX AREAS
REAR TORQUE BOX AREAS
UNITIZED CONSTRUCTION
FRONT TORQUE BOX AREAS

B. Pinchwelds (FIG. 1-4)

1. Are used in most unibody and some perimeter frame designs
2. Refer to the weld fusing the bottom flange of the outer rocker panel to the inner rocker panel
3. Are the strongest areas of unibody construction for lifting and supporting

FIGURE 1-4


FLOOR MAT
STEP PLATE
CROSS-MEMBER CONSTRUCTION
ROCKER PANEL
FILLER PAD
INNER ROCKER PANEL
PINCH WELD
OUTER ROCKER PANEL

IV. Principles of lifting, jacking and supporting vehicle

A. The purpose of supporting the vehicle is to get the vehicle high enough in the air safely so that an inspection of the underside can be made, using measuring equipment.

B. In lifting or jacking a vehicle, check both the vehicle and equipment manufacturer's recommendations.

C. In getting the vehicle off the ground, there are two separate points to be considered: proper lifting or jacking methods and proper supporting methods.

D. In general, the proper *supporting* points for frame-body vehicles will be the torque box areas.

E. In general, the proper *supporting* points for unitized vehicles will be on pinchwelds near torque box areas.

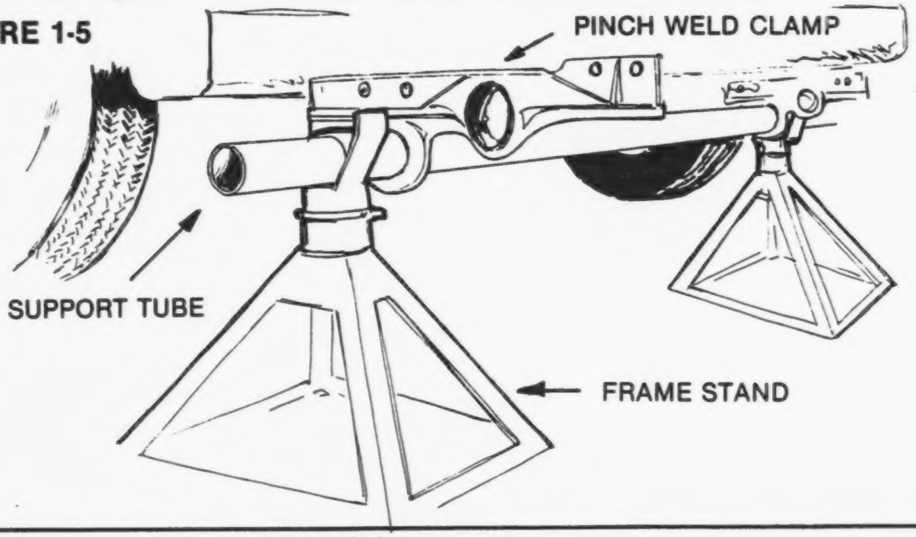
F. Some equipment manufacturers recommend that for purposes of measuring damage, both frame-body and unitized vehicles be supported at the four load-bearing areas of the suspension. The supports are generally placed under the lower control arms, or suspension stands are employed which attach to the wheel lugs.

G. Principles of raising the vehicle for placement of supports in torque box areas

  1. Because the torque box areas are usually used to support the vehicle, it is not possible to place a jack directly on the torque box areas (the jack would obstruct the support.)

  2. Most unibody vehicles can be raised by attaching pinchweld clamps to the pinchwelds, with support tubes placed between the pinchweld clamps. The vehicle is raised one end at a time by using a jack under the center of the support tube. Support stands are then placed under the ends of the support tubes. (FIG. 1-5), (FIG. 1-6)

FIGURE 1-5



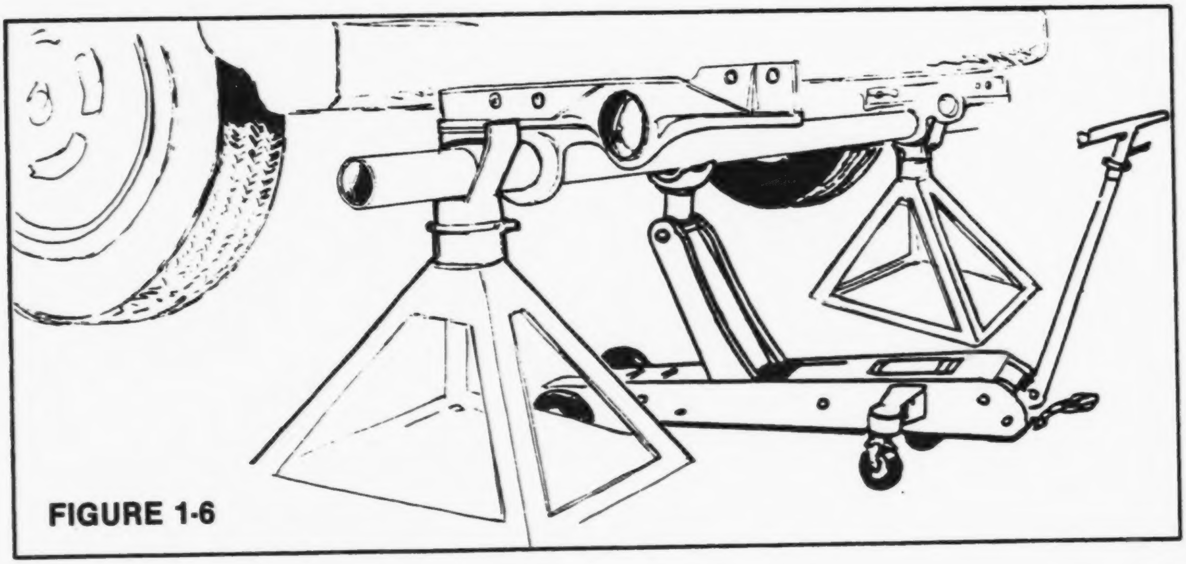


FIGURE 1-6

3. Frame-body vehicles can be raised on either a crossmember or a frame rail. Generally a jack is placed under the center of the front or rear crossmember to raise the vehicle high enough to locate support stands under the torque boxes. (FIG. 1-7)

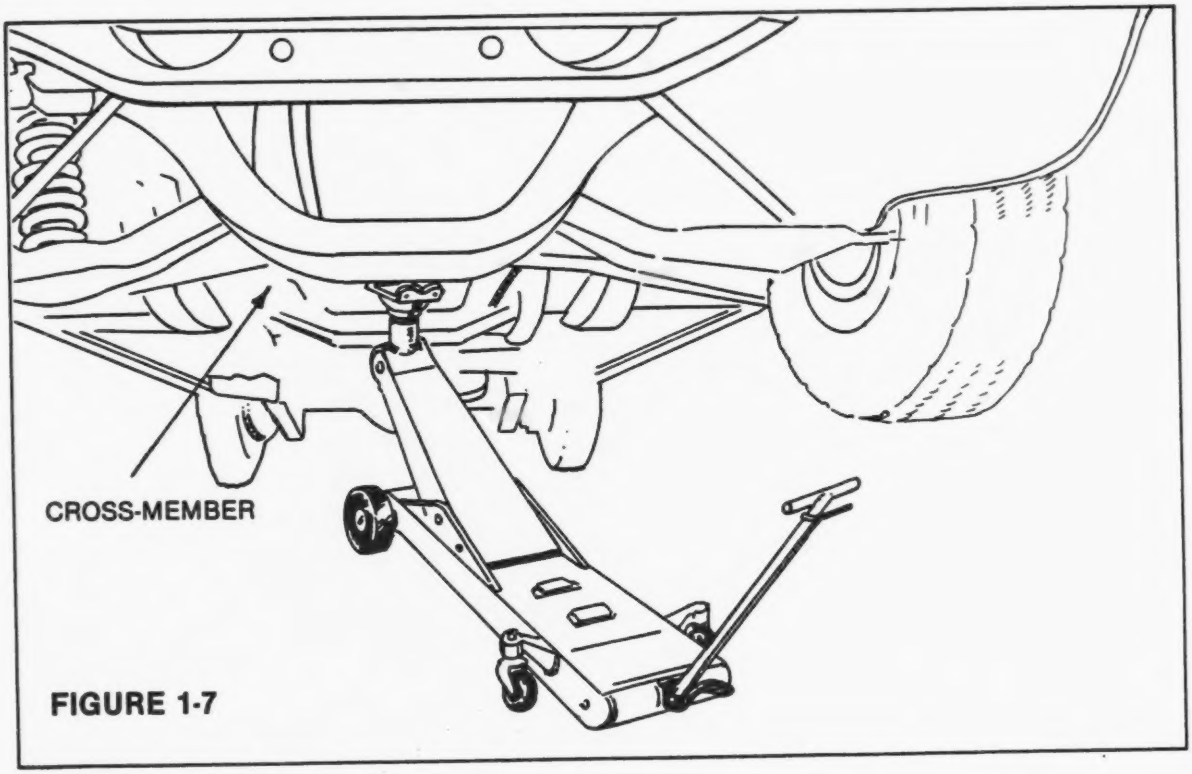


FIGURE 1-7

4. Another jacking and supporting method must be found for unibody vehicles without pinchwelds. Also, it might be necessary to raise the vehicle just to have clearance for pinchweld clamps.

   *(**CAUTION:** Identification of proper lifting and jacking points is extremely important. Damage caused by improper lifting and jacking can be severe. Common sense, along with an understanding of vehicle construction and vehicle supporting techniques, must be used in each repair instance.)*

ASSIGNMENT SHEET #1, LESSON ONE

IDENTIFY PROPER LIFTING, JACKING AND SUPPORTING TECHNIQUES

I. Directions

A. Your instructor will provide vehicle specification manuals, and equipment specification manuals for vehicles and equipment available in your shop.

B. Visually examine specified vehicles in shop and read vehicle specifications pertinent to lifting, jacking and supporting.

C. Read equipment manufacturer's specifications for operating lifting, jacking and supporting equipment.

D. Complete assignment sheet below.

Vehicle # 1

Make and model: ______________________________

Describe proper lifting and supporting procedure according to directions below (be specific).

A. Device(s) used to raise vehicle:

Front: ______________________________

Rear: ______________________________

B. Location(s) of device(s) used to raise vehicle:

Front: ______________________________

Rear: ______________________________

C. Supports used to support vehicle:

Front: ______________________________

Rear: ______________________________

D. Location of supports used to support vehicle:

Front: ______________________________

Rear: ______________________________

E. Describe procedure for lifting and supporting vehicle:

(2 points) ______________________________

____

____

Vehicle # 2

Make and model: ______________________________

Describe proper lifting and supporting procedure according to directions below (be specific).

A. Device(s) used to raise vehicle:

Front: ______________________________

Rear: ______________________________

B. Location(s) of device(s) used to raise vehicle:

Front: ______________________________

Rear: ______________________________

C. Supports used to support vehicle:

Front: ______________________________

Rear: ______________________________

D. Location of supports used to support vehicle:

Front: ______________________________

Rear: ______________________________

E. Describe procedure for lifting and supporting vehicle:

(2 points) ______________________________

____

____

(NOTE: The evaluation on the above assignment sheet is the evaluation for competency C5 "Describe proper lifting and jacking techniques." _______% = Mastered {3}; _____% = Limited supervision {2}; _____% = Needs supervision {1}; _____% or below = Student should be re-evaluated {N}.)

MODULE: INTRODUCTION TO AUTO BODY

UNIT V: RAISING AND SUPPORTING VEHICLES

UNIT V TEST

PART I—LIFTING TERMS

I. Match the definition in the left column with the correct term in the right column.

_____1. Specially built supports. They are designed specifically for supporting vehicles during frame repair procedures.

_____2. Raising a vehicle off the ground with a device that puts pressure only on one small area, such as a hydraulic floor jack.

_____3. Raising a vehicle off the ground with a device that puts pressure on a large area or areas.

_____4. Fuses the outer rocker panel to the inner rocker panel.

_____5. Either using stands to hold the vehicle high enough to allow measuring systems to be employed, or using a bench.

_____6. Designed to be placed between two pinchweld clamps to provide lifting and supporting points.

_____7. Design used in both conventional frames and unibody construction, in which each corner of the passenger compartment is made with a twist-absorbing design.

_____8. Each corner of the passenger compartment.

A. Torque box area

B. Pinch weld

C. Frame stands

D. Support tube

E. Torque box

AB. Jacking

AC. Lifting

AD. Jack stands

AE. Supporting

PART II—LIFTING EQUIPMENT

I. Mark a T on the test or answer sheet if the statement is true and an F if the statement is false.

_____9. The most common type of pneumatic floor jack is the hydraulic floor jack.

_____10. The bumper-type end lift will not work on some vehicles.

_____11. Hydraulic floor jacks are used often to support a vehicle.

_____12. If using an approved floor jack or bumber-type end lift that has a safety catch, it is alright to work on a vehicle that is supported by the jack or lift.

_____13. After raising a vehicle with a floor jack, be sure the handle of the jack is pointed straight out.

_____14. Hydraulic lifts must not be operated if the vehicle doors, hood or deck are open.

PART III--LIFTING AND SUPPORTING AREAS

I. Mark a T on the test or answer sheet if the statement is true and an F is the statement is false.

_____15. Torque box areas are present in both frame-body and unitized designs.

_____16. Torque boxes are designed to absorb twist forces, making for smoother riding in frame-body vehicles.

_____17. Torque boxes are designed to absorb twisting forces in a collision, routing damage toward the passenger compartment.

_____18. There are always six torque box areas per vehicle.

_____19. Some vehicles do not have torque boxes, but the corners of the passenger compartment are still called torque box areas.

_____20. Torque box areas are generally the strongest areas for lifting and supporting.

_____21. Rocker panel pinchwelds are used in unibody and some perimeter frame designs.

_____22. Pinchwelds on the rocker panels are the strongest areas of unibody construction for supporting the vehicle.

PART IV--PRINCIPLES OF LIFTING AND SUPPORTING

I. Mark a T on the test or answer sheet if the statement is true and an F if the statement if false.

_____23. Proper lifting methods and proper supporting methods are not necessarily the same.

_____24. Some equipment manufacturers recommend using suspension stands, which attach to the wheel lugs and support the vehicle.

_____25. Frame-body vehicles can be raised on either a crossmember or a frame rail.

_____26. Unibody vehicles are usually raised by placing a jack on a frame rail.

_____27. After pinchweld clamps are attached to a unibody vehicle, it can be raised using a support tube.

_____28. If a unibody vehicle does not have pinchwelds, it must be supported with a bumper-type end lift.

_____29. Damage cause by improper lifting and jacking is seldom severe, but you should be careful anyway.

_____30. To properly and safety lift a vehicle you should always read the vehicle manufacturer's recommendations for lifting and jacking.

(NOTE: Completion of this portion of the unit test is the evaluation for Compentency C5 "Describe proper lifting and jacking technique." Of the 30 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this portion of the test.)

ANSWERS TO UNIT V TEST

PART I.

1. C
2. AB
3. AC
4. B
5. AE
6. D
7. E
8. A

PART II.

9. F
10. T
11. F
12. F
13. F
14. T

PART III.

15. T
16. T
17. F
18. F
19. T
20. T
21. T
22. T

PART IV.

23. T
24. T
25. T
26. F
27. T
28. F
29. F
30. T

MODULE: INTRODUCTION TO AUTO BODY

UNIT VI: SAFETY

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify proper safety procedures in all aspects of the auto body field. Mastery will be evidenced by scoring _____ percent on the unit test and by demonstrating safe practices whenever the student is in the shop.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Identify government agencies regulating the auto body industry (OSHA, EPA) (Competency D1, Part V of Unit VI test)

II. Identify general safety rules (Competency D2, Part I of Unit VI test)

III. Use protective clothing and equipment (Competency D3, Part III of Unit VI test)

IV. Identify the proper use of fire protection equipment (Competency D4, Part IV of Unit VI test)

V. Use chemicals safely (Competency D5, Part II of Unit VI test)

MODULE: INTRODUCTION TO AUTO BODY

UNIT VI: SAFETY

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

  1. Lesson 1: General Safety in the Body Shop

    a. Information outline

  2. Lesson 2: Materials and Tools

    a. Information outline

    b. Handout #1: Safety pledge

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Show students shop layout and familiarize them with the location of circuit breakers, fire-fighting equipment, first-aid kit and emergency telephone.

B. Go over current EPA and OSHA regulations that apply to your shop.

C. Demonstrate the correct use of fire-fighting equipment.

D. Demonstrate the correct use of protective clothing and equipment.

E. Show students the location of dangerous materials and chemicals in your shop. Go over the correct storage of dangerous materials, and the correct disposal of them.

F. Have students and their parents sign a safety pledge, such as the one provided in this unit (or your own school's safety pledge).

G. Have students pass the safety test with an appropriately high score, as set by your school, before letting them work in the shop.

REFERENCES USED IN WRITING THIS UNIT

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3. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.
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MODULE: INTRODUCTION TO AUTO BODY

UNIT VI: SAFETY

LESSON ONE: SAFETY IN THE BODY SHOP

(NOTE: Safety in the body shop is the responsibility of everyone working in the body shop. Safety in the shop means protecting yourself and others from injury at all times. Working in the body shop requires working with a great variety of materials and equipment which can injure you and others around you if not properly handled. Safety in the shop includes: following federal guidelines for safe practices, keeping the shop free of hazards, using protective clothing and equipment, correct handling and use of materials containing potentially harmful chemicals, correct use of hand tools, power tools and power equipment and welding safety. Tool safety is covered in Unit III and Unit IV of this module.)

I. **Following federal guidelines for safe practices**

A. Two federal agencies oversee safety in the work place.

1. OSHA (Occupational Safety and Health Administration)

2. EPA (Environmental Protection Agency)

B. Both OSHA and EPA issue guidelines for safety which must be followed.

C. OSHA issues guidelines concerning safety for the worker.

D. EPA issues guidelines concerning safety for the environment.

E. OSHA guidelines

1. Each school will have a copy of OSHA guidelines which must be followed.

2. Due to the changing nature of OSHA guidelines, your instructor will go over current OSHA guidelines with you. All students are required to follow OSHA guidelines.

3. OSHA guidelines concern the correct labeling of hazardous components of equipment, the correct storage of equipment and materials, the use of protective clothing and equipment, the placement of warning and safety signs, and general safety practices.

F. EPA guidelines

1. Each school will have a copy of EPA guidelines which must be followed.

2. Due to the changing nature of EPA guidelines, your instructor will go over current EPA guidelines with you. All students are required to follow EPA guidelines.

3. EPA guidelines concern any materials which may be hazardous if released into the environment, including the environment of the shop.

4. Special EPA concerns related to auto body repair
    a. Using air-supply respirators when working with paints containing toxic materials, and when welding on materials which may release toxic gases
    b. Proper handling, storage and disposal of hazardous chemicals
    c. Correct handling, storage and disposal or hazardous materials

II. **General safety rules**

A. During the course of working in the shop, the body shop technician will be moving from one area of the shop to the other, moving parts and equipment around the shop, and performing varied activities. It is important that the shop floor be free of hazards which would cause technicians to slip or trip.

B. In a wide variety of shop activities, waste materials are produced which can cause dangerous situations unless the waste materials are disposed of or stored properly.

C. Always be sure that shop exits are well-marked with an "EXIT" marking and are clear of obstructions.

D. To help keep yourself and the shop free of hazards, always follow these personal safety rules.

1. Work quietly and give the job at hand your complete attention.
2. Do not operate any piece of equipment unless you have been instructed in the use of the equipment.
3. Even if you have been instructed in the use of a piece of equipment, do not use it unless you have the specific permission of the instructor.
4. Keep tools and equipment under control at all times.
5. Do not use tools for any purpose other than their specifically stated purpose.
6. Do not leave creepers laying on the floor. Always stand them against the wall, wheels outward, when not in use.
7. Never indulge in horseplay in the shop. You could injure someone, or someone else could injure you.
8. Always make it a practice to assess the safety of any situation in which you find yourself.
9. Always wear protective clothing and equipment in any situation where it is necessary.
10. Do not wear rings, bracelets, watches or necklaces when working around moving machinery or electrical equipment. Jewelry can catch in moving machinery with serious consequences. Also, if a ring or bracelet should accidentally create a short circuit of a car battery, the metal of the ring or bracelet could become white-hot in an instant, causing a serious burn.

11. Do not put sharp objects into your pockets. They could stab you if you change positions or could injure a vehicle's interior if you sat down in the interior with a sharp object in your pocket.

12. Never use compressed air to blow dirt from your clothes and never point a compressed-air hose at another person.

13. Keep your hands free from oil and grease.

14. Keep tools, especially tool handles, free from oil and grease.

15. Wipe up grease and other spills from the shop floor immediately, or at least put an oil-absorbing compound over them.

16. When cleaning up flammable liquids, always dispose of the rags in a container approved for holding flammable rags.

17. Do not look in the direction of another person who is using an electric welder.

18. Do not run a vehicle engine inside a closed garage unless the vehicle exhaust is hooked up to a ventilation system. Carbon monoxide is present in the exhaust and enough to kill you can collect in a very short time.

19. Do not smoke in any body shop, except in an area designated for smoking, such as the office.

20. When pumping a flammable liquid from a large container into a small one, be sure to first attach a bond and ground wires to keep a spark from jumping from the nozzle into the small container.

21. Always be on the alert for hazardous situations in the shop. Correct them as you find them and inform your instructor of the situation.

22. If road-testing a vehicle, always fasten your seat belt, even if only going a short distance.

23. Disconnect the starting battery as soon as any car is brought into the shop. This eliminates hazards from shorts, which may have resulted from the accident or which could result from repair procedures.

    *(**CAUTION:** Vehicle manufacturer's recommendations must be followed for disconnecting batteries. Some on-board vehicle computer systems can be damaged if the battery is incorrectly disconnected.)*

24. Torn and damaged sheet metal removed from a vehicle should be disposed of properly. If left on the shop floor, someone could come into contact with the sharp edges and be seriously injured.

25. When parts are removed from a vehicle they should be stored on a bench, or, if large parts, against a wall.

26. Asbestos particles can cause cancer. Asbestos is found in brake shoes and clutches. Therefore, wear a particle mask when doing any cleaning work on brake or clutch parts and do not use compressed air to clean brake or clutch parts.

27. Do not let the leads on testing equipment fall into the fan of a vehicle while the engine is running. When working around the fan motor of a transverse-mounted engine, disconnect current-supply wire to the motor. Such fan motors can turn on even with the engine off.

28. When using air for cleaning purposes the air must not be more than 30 psi.

29. Never play with fire extinguishers.

30. Always read the labels on chemicals and materials.

E. Emergencies

1. If someone is injured in the shop, notify your instructor at once.

2. Do not give first aid to a victim unless you know what you are doing, but if you have had proper first-aid training, then do not hesitate to give first aid.

3. If someone comes into contact with electrical current and receives a shock which immobilizes them, do not try to move them if the current is still on and they are still in contact with it. Shut off the main circuit to the shop. Touching someone in contact with electrical current will cause the electrical current to pass through you.

F. Safety procedures in preparing vehicle for damage analysis or for frame-straightening procedures

1. Mask broken glass with tape and label "Danger."

2. Grind down sharp metal edges.

3. Clean up all leaking fluids.

4. Remove the fuel tank.

5. Disconnect the battery.

6. Keep your eyes open and alert for potential safety hazards at all times.

7. Double-check hookups to make certain they are secure. Do not wrap chains around sharp edges.

8. Mask or cover all broken glass and label "Danger." Tape any glass that could break during pulling procedures.

9. Use just enough pressure to do job and stop pulls frequently to check equipment and progress of pull.

10. Use only appropriate equipment and make sure all equipment is in good working order before starting a pull.

11. Do not damage hydraulic hoses. Avoid heat, sharp objects, or rolling heavy objects over the hoses.

12. Keep yourself and others away from the line of the pull and keep your hands and body well away from equipment and attachments during pulling operations. Inform everyone in the shop prior to making a pull.

13. Double-check all hookups before starting pull and attach a secondary safety chain or cover chain.

G. Working with glass

1. Safety is extremely important in working with vehicle glass.

2. Protect vehicle interior and exterior with covers.

3. Protect self with safety glasses and heavy gloves.

4. Handle glass carefully.

5. Use steel-toed shoes.

6. When carrying glass hold it so it can only fall away from you.

7. Do not hold glass such that the flat surface of the glass is facing up. Hold it so that the flat surfaces face to the sides. Hold onto the edges of the glass, with palm of lower hand turned outward. Two people carrying glass should hold it the same way. Never carry glass under your arms.

H. Welding safety

(NOTE: The following are general safety rules for welding equipment that even those workers who are not familiar with welding equipment should know. The Welding Module's section on safety should be reviewed fully before any student is allowed to use welding equipment.)

1. Safety for all welding equipment

    a. When using welders, protect those around you with protective enclosure which protect others from the dangers of arc rays or acetylene flames.

    b. Never drag cables or hoses of any type of welder through dirt or oil, and never pull on a cable to force it over an obstruction.

    c. Many welding activities produce toxic fumes and vapors that are hazardous to breathe, and every work station should be equipped with a ventilation or exhaust system capable of safely removing dangerous and irritating smoke and contaminants.

    (CAUTION: *Always position your head to the side of rising fumes.)*

d. In confined areas where the hazard of toxic fumes is increased, a welder should wear an air-supplied respirator or a self-contained breathing apparatus, not a filter-type mask that cannot compensate for oxygen displacement.

(**CAUTION:** *Argon is much heavier than air and will quickly displace oxygen, so be especially careful using the MIG process in confined areas, even though they appear to have adequate ventilation.)*

2. Safety for electric welders

a. Keep work area, equipment, and clothing dry when using electric welders because even a slight amount of moisture can conduct enough electricity to cause a severe shock.

b. Never drape an electric welding cable over any type of gas cylinder, and *never* strike an arc on a gas cylinder.

c. A welding arc produces ultraviolet and infrared radiation that can severely burn eyes that are unprotected with a proper shade of protective lens.

(NOTE: A welding hood or helmet protects the head from flying sparks, but the shaded lens protects the eyes.)

d. Radiation from a welding arc is strong enough to sunburn or sometimes blister bare skin if the exposure is intense or for an extended period, so arms, legs, and torso should be covered with durable flame-resistant clothing.

e. Always wear heavy gloves approved for use with an electric welder.

3. Safety for oxyacetylene welding

a. Oxygen and acetylene tanks must be stored in a ventilated area and must be kept separate. There should be at least 20 feet between oxygen cylinders and acetylene cylinders.

b. *Never* allow oil or grease to come in contact with oxygen under pressure.

(Note: No lubrication of apparatus is necessary.)

c. Never use oxygen as a substitute for compressed air.

d. Before starting to weld or cut, make certain there is no flammable material nearby.

e. Always wear welding goggles and heavy gloves when working with a lighted torch.

f. Do not use matches for lighting acetylene torches.

(**CAUTION:** *Hand burns may result from this practice.)*

   g. Do not relight oxyacetylene flames on a hot work section in a small confined space.

      (CAUTION: *Acetylene gas gathers in one spot.)*

   h. Never use acetylene at pressure above 15 psi.

   i. Arrange for good ventilation when welding on brass, bronze or galvanized materials.

      (CAUTION: *Some of the gases given off are poisonous.)*

   j. When cutting iron or steel coated with lead or paint containing lead, always wear a suitable breathing apparatus.

   k. Use particular caution when welding or cutting in dusty or dirty locations.

      (CAUTION: *Dust can explode.)*

4. Safety for gas cylinders

   a. All gas cylinders must be secured in both the storage area and the wheeled cart with a safety chain or approved lashing.

   b. The protective caps must be in place any time the cylinders are not in use.

   c. Move only with protective caps in place.

   d. Do not drop or knock cylinders around.

   e. Never tamper with safety devices or markings on a cylinder.

   f. Never use a hammer or wrench to open a cylinder valve.

   g. Make sure you can handle a cylinder before attempting to move it.

   h. Always move a gas cylinder by tilting it a little toward you and rolling it on the bottom edge of cylinder with cylinder in upright position.

      (CAUTION: *Do not tilt cylinder too far over center; it may cause cylinder to drop.)*

I. Lifting safety

1. Working in the body shop the technician will encounter many situations in which heavy objects must be lifted from the floor.

2. Back injuries are common if lifting is not done properly.

3. Rules for properly lifting heavy objects

   a. Avoid lifting, if possible.

  b. Move heavy objects by pushing, pulling, rolling or sliding.

  c. Use hoists, jacks, carts and wheel trucks when possible.

4. If there is any doubt about your ability to lift something, use a mechanical device or get the assistance of another person.

5. Steps of procedure to lift an object (FIG. 1-1)

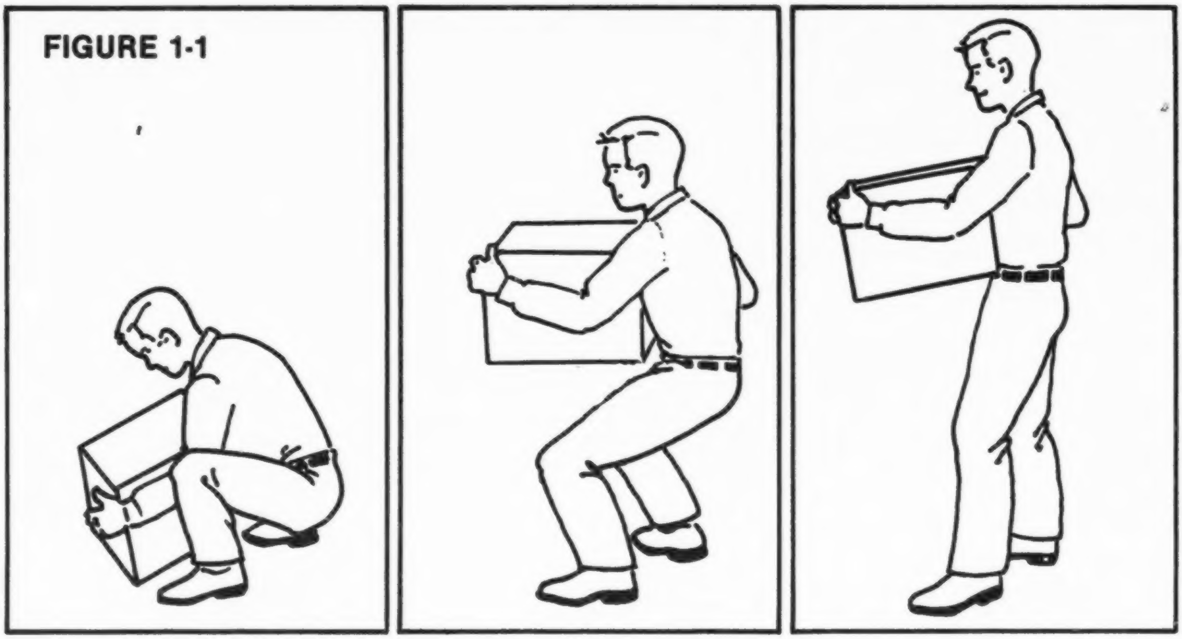


FIGURE 1-1

  a. Do not lift in an area where there is a wet or greasy floor.

  b. Spread your feet slightly, until comfortable, with one foot slightly ahead of the other and along side the object.

  c. Bend your knees, kneel or squat (Do not bend your back).

  d. Use blocking under objects to get a hand hold.

  e. Get a good grip and use gloves if object has sharp or jagged surfaces.

  f. Lift with your leg, arm and shoulder muscles, straightening the legs and coming to a standing position.

  g. Shift your feet to turn -- do not twist.

  h. Lower the load by bending the knees, keeping the back straight and using leg and arm muscles, and keep fingers and toes clear of objects.

III. Protective clothing and equipment

A. Always wear proper clothing.

1. Wear well-fitting, heavy clothes with close-fitting cuffs (buttoned up) and shirt pockets with flaps over them.

2. Wear leather shoes with nonskid soles. Wear steel-toed safety boots in situations requiring them.

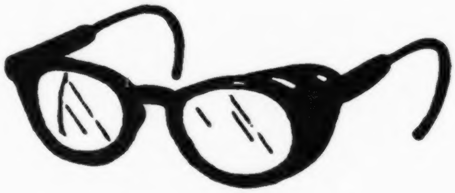
3. Keep long hair out of machinery by wearing a cap.

B. Always wear proper protective equipment.

1. Wear safety glasses in situations where there is any danger of flying objects. (FIG. 1-2)

   (NOTE: Your school may require you to wear saftey glasses whenever you are in the shop.)

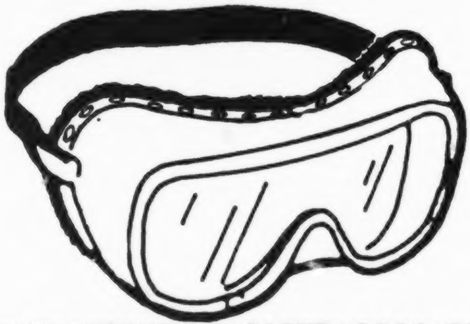
FIGURE 1-2



SAFETY GLASSES

2. Wear splash-resistant safety goggles in situations where paint or chemicals could come into contact with your eyes. There are two kinds, dust-and-impact resistant, and splash resistant. Be sure to wear the correct kind in the correct situation. (FIG. 1-3)

FIGURE 1-3

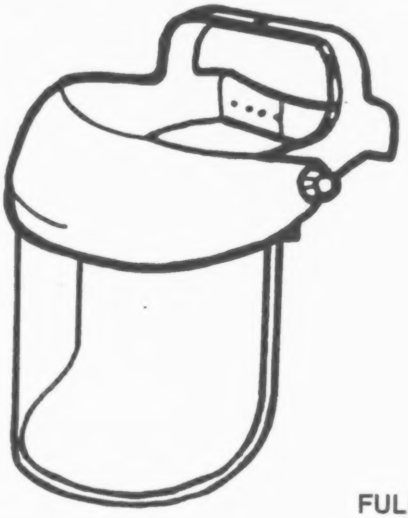


SPLASH-RESISTANT SAFETY GOGGLES

(CAUTION: *Never use safety glasses when safety goggles are required. Safety goggles seal the eyes from sprays and mists, while safety glasses do not.)*

3. Wear a full face shield in situations where sharp flying objects could injure your face. (FIG. 1-4)

FIGURE 1-4



FULL FACE SHIELD

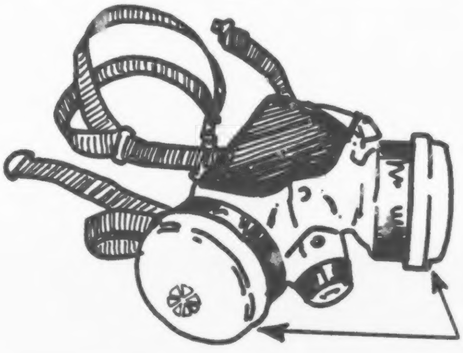
4. Use breathing protection when working with any materials or chemicals which could be hazardous if inhaled.

   (NOTE: There are many such materials which will be used often in the body shop, including many fillers and painting materials.)

C. Breathing safety equipment for refinishing

1. Respirator with removable filters (FIG. 1-5)

FIGURE 1-5



REMOVABLE FILTERS

a. Filters out paint particles and most paint fumes by filtering air being breathed

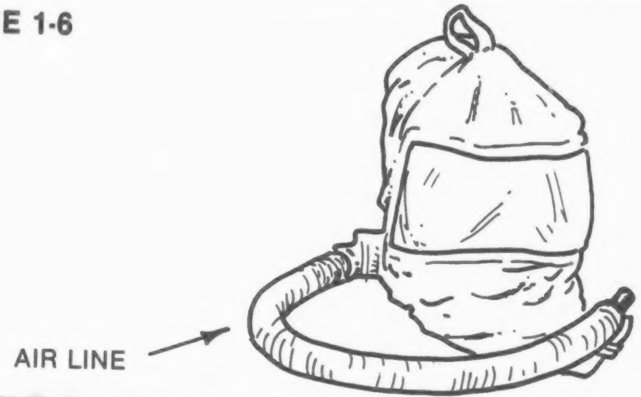
b. Filters must be replaced -- never cleaned

c. Replace filters after each complete paint job

d. Some type of respirator is absolutely necessary for safe paint work and a respirator with removable filters is recommended for most activities.

2. Air-supply respirator (FIG. 1-6)

FIGURE 1-6



a. Provides air to be breathed through air line

b. Hose assembly belted to waist to avoid damaging hose

c. Recommended when working with toxic paints, such as paints with isocyanates.

3. Charcoal mask

a. Filters particles and fumes from the air being breathed

b. Is effective for use in some spraying situations

c. Consult manufacturer's recommendations to determine the types of paints and the amount of painting time for which they are effective.

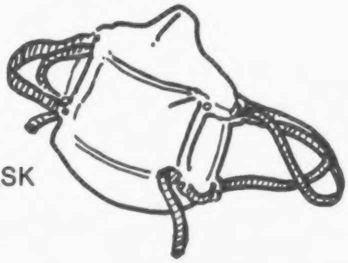
4. Particle mask (FIG. 1-7)

a. Disposable mask used for sanding operations

b. Keeps particles of refinish material and metal dust from getting into worker's lungs.

c. Should be used in all sanding operations

FIGURE 1-7



PARTICLE MASK

D. Gloves

a. Rubber gloves should be worn whenever working with paints, thinners, plastic filler and many other refinishing materials -- follow label recommendations on material with which you are working.

b. Heavy leather gloves with gauntlets should be worn in sanding and grinding operations.

IV. **Fire protection equipment**

A. Fire is an ever-present danger in an auto body shop, where there are numerous flammable materials and numerous situations where they could be ignited, if proper care is not taken.

B. The first line of defense against fire is to know where fire extinguishers are located and how to use them.

C. The second line of defense is to know where the fire alarm is and to activate it at the first sign of a fire which has any possibility of getting out of control.

D. Another defense against fires is the fire blanket.

1. The fire blanket is a flame-retardant blanket which is used to wrap up a victim whose clothes are on fire.
2. If someone's clothes catch on fire, act quickly to bring the blanket. Wrap the blanket around the person to smother the fire.

E. Types of fires

1. A - Ordinary combustibles, such as wood, paper and cloth
2. B - Flammable liquids and grease, including gasoline, paints and oils
3. C - Electrical equipment, such as motors, switches, etc.
4. D - Combustible metals, such as magnesium, iron

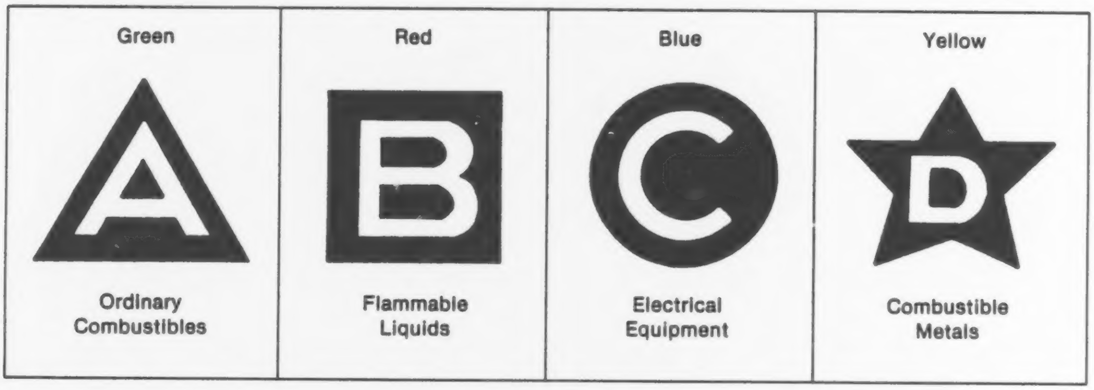
F. Types of fire extinguishers

1. Class A - Plain water
2. Class B,C - May be carbon dioxide, ordinary dry chemical, or halon
3. Class A,B,C - Multipurpose dry chemical
4. Class D - Dry powder

(NOTE: Your instructor will demonstrate the proper operation of the fire protection equipment available in your shop.)

G. Universal symbols for fire extinguishers (FIG. 1-8)

FIGURE 1-8


Green
Red
Blue
Yellow
A
B
C
D
Ordinary Combustibles
Flammable Liquids
Electrical Equipment
Combustible Metals

V. **Hazardous chemicals and materials**

A. Areas where hazardous chemicals are encoutered

1. Hazardous materials are encountered in many situations in the auto body field.
2. Many of these materials are highly toxic and can kill you unless safety precautions are followed.
3. Situations where hazardous materials are encountered
    a. Working with paint and refinishing material
    b. Working with plastic and fiberglass fillers
    c. Working with gasoline
    d. Working with batteries
    e. Working with air conditioning systems

B. Paint and refinishing operations general safety

1. Do not wash materials from hands with paint thinner or reducer--they can cause a rash and can even be absorbed through the skin causing liver damage.
2. Wear rubber gloves when handling paint and other refinishing material.
3. Paints and thinners should always be kept in closed containers.
4. All painting should be done in the spray booth.
5. You must follow all safety procedures recommended by the manufacturer of the material with which you are working.
6. Corrosion-protection materials may be hazardous. The use of rubber gloves, eye protection, protective clothing and a respirator is recommended for many applications. Follow the directions on the label.
7. Always wear recommended protective clothing.
8. Do not allow any unprotected person in the work area of sanding, grinding or spraying operations.
9. Always obey instruction and caution labels on all refinishing materials.
   a. Protect yourself against inhaling or swallowing fumes.
   b. Protect yourself against contact with eyes or skin.
10. *Never* use compressed air to dry your skin or to remove dust from skin or clothes.

    (NOTE: Compressed air is released with enough pressure to put out an eye.)
11. Never place your bare hand over the outlet nozzles of spray equipment when spraying.
12. Do not overload circuits by connecting extra electrical equipment to a circuit in or near a paint room or paint material storage area. Most paint materials are flammable and some are explosive.
13. Paint fumes can cause headaches and stomachaches and some paint fumes are poisonous.
14. Paint particles (atomized droplets of paint in the air) can cause breathing problems because they will stick to your lung's air passages and partially clog the breathing system.
15. Paints and paint products can damage your eyes
    a. All paint products are capable of causing some eye trouble.
    b. Some paint products are capable of blinding you if splashed into your eyes.
    c. The dust from sanding paint can get into and damage your lungs.

16. Skin on hands can become irritated from constant exposure to painting materials.

17. Many paint products, contain isocyanates. If the paint used contains isocyanates, it is mandatory that an adequate respirator be worn. An air-line respirator with a full hood or half mask is recommended. If not available, use a respirator that is approved for used with isocyanate vapors and mists.

18. For the above reasons, breathing equipment, eye protection and gloves are *absolutely* necessary for refinishing procedures.

C. Plastic filler

1. When using plastic body filler, apply only in a properly ventilated area.

2. Do not apply excessive heat in warming a surface for plastic filler.

3. Always use a particle mask when sanding or grinding plastic filler. The dust from plastic fillers is very harmful if it gets in your lungs.

D. Fiberglass filler

1. Always wear safety goggles when working with fiberglass resin. If one drop of hardener gets in your eye it will progressively destroy eye tissue and result in blindness. If the hardener gets in your eye, it must be flushed within four seconds.

2. In fiberglass repair, you will be using epoxy resin, a substance which can also cause skin irritation if safety rules are not strictly followed.

    a. Always wear rubber gloves when handling resin or fiberglass.

    b. Resin mixtures are very toxic and should be used only in well-ventilated areas.

    c. The mixing of resin and hardener causes a chemical reaction which produces heat, which could cause a fire. Keep a bucket of water handy for disposal of leftover materials.

3. When grinding or sanding fiberglass *you must* wear a respirator, face shield, safety glasses and heavy gloves. Button up shirt collar and cuffs and add elastic or rubber bands around cuffs.

    a. Fiberglass is made from molten glass which has been drawn out into tiny thread-like fibers.

    b. When these fibers are worked with a grinder or sander, they break up into millions of small particles of glass.

    c. These particles, if inhaled, can cause respiratory illness.

    d. Fiberglass particles that settle on unprotected parts of the body can cause a serious skin irritation.

4. Do not allow heat or flame near fiberglass resin, which is highly explosive.

E. Safety in working with gasoline

1. A spark or open flame in a closed place filled with gasoline vapor can cause an explosion. Even the spark from a light switch can set off an explosion.

2. If gasoline leaks from a vehicle, the shop door should be opened and the ventilating system engaged. Gasoline spilled on the shop floor should be wiped up immediately, and the rags used properly disposed.

3. Fix gasoline leaks on vehicles as soon as possible, following proper procedure.

   (NOTE: If a gasoline leak must be fixed on a vehicle, your instructor will know the proper procedures.)

4. Store gasoline only in approved safety containers. Never store gasoline in glass container.

F. Vehicle batteries

1. Vehicle batteries contain a solution of acid and water called electrolyte, which is extremely hazardous and requires immediate first aid if it comes into contact with skin or eyes.

2. Eye Contact

   a. Immediately flush with water for at least fifteen minutes.

   b. Seek medical attention immediately.

   c. If medical assistance is not available, neutralize acid with baking soda and water solution (2 tablespoons baking soda in 2 cups of water).

3. Skin Contact

   a. Remove clothing from affected area.

   b. Wash area with plenty of soap and water for at least five minutes.

   c. Seek medical attention if blistering, burning, or peeling occurs.

4. General safety in working with batteries

   a. Remove all jewelry before disconnecting battery cables or working on any electrical circuit.

   b. Remove ground (negative) cable from battery before removing positive cable.

   c. Disconnect battery cables before using ohmmeter.

   d. Do not ground output terminal of alternator.

   e. Never lay a conductor across the battery terminals.

f. Disconnect battery before replacing electrical components.

g. When using jumper cables always connect ground cable to frame or engine.

h. When using a battery charger, disconnect battery cables and connect charger to battery prior to turning on charger.

G. Air conditioning systems

(CAUTION: *Safety is extremely important in working with air conditioning systems due to the presence of R-12 gas in the system).*

1. Always wear safety goggles when opening R-12 lines.

2. Do not weld or steam-clean on or near the air conditioning system or discharge air conditioning vapor into area where a flame is exposed.

3. Do not expose eyes to liquid.

4. Avoid breathing smoke and fumes produced by the burning of the R-12. Such fumes may be hazardous.

5. If R-12 should strike the eyes, call a doctor immediately. In the meantime:

    a. Do not rub the eye. Splash the affected area with COLD water to get the temperature above the freezing point.

    b. Apply an antiseptic oil, which is helpful in providing a protective film over the eyeball to reduce the possibility of infection.

6. Should R-12 come into contact with the skin, treat the same as skin which has been frostbitten or frozen.

7. Even if all refrigerant has been removed from system, proceed cautiously, regardless of gauge readings. Open valves very slowly, keeping face and hands away so that no injury can occur.

HANDOUT #1, LESSON ONE

SAFETY PLEDGE

It is understood that each student will be given proper instruction in the use of the equipment and in the correct safety procedures concerning the equipment before she or he will be allowed to operate it. The student must assume responsibility for following safe practices. We, therefore, ask that the student subscribe to the following safety pledge.

I will follow all safety rules.

I will never operate tools or equipment without first having permission from my instructor or supervisor.

I will not ask permission to use a particular tool or piece of equipment unless I have been instructed in its use.

I will report immediately any accident or injury, no matter how minor, to my instructor or supervisor.

Student's signature ______________________________

Date ________________

Supervisor's or instructor's signature ______________________________

Date ________________

Parent's or guardian's signature ______________________________

Date ________________

(Parental consent is necessary if the student is under 18.)

MODULE: INTRODUCTION TO AUTO BODY

UNIT VI: SAFETY

UNIT VI TEST

PART I–GENERAL SAFETY RULES

I. Select the best answer from the choices listed.

_____1. Technician I says that many materials are present in the body shop which can be hazardous unless stored properly.

Technician II says that many materials are present in the body shop which can be hazardous unless disposed of properly.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____2. Technician I says that it is alright to use a piece of equipment anytime, provided you are sure you know how to use it.

Technician II says that you should not use a piece of equipment unless you instructor has given you permission.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____3. Technician I says that many tools can serve many purposes. For example, a claw hammer can be a trim removal tool.

Technician II says that most tools are designed for one purpose only and you should not use a tool for any purpose other than their specifically stated purpose.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____4. Technician I says that you should not wear any rings or bracelets unless they are made of at least 14 karat gold.

Technician II says that you should not wear shirts with flaps over the pockets.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____5. Technician I says that you should store creepers under vehicles so they are out of the way.

Technician II says that creepers should be stored standing against a wall.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____6. Technician I says that if you put sharp object into your pocket you should first wrap it in a clean rag.

Technician II says that you should never put sharp objects into your pockets.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____7. Technician I says the quickest way to get clean after being in the shop is to use an air compressor to blow dust off of yourself, provided you do not exceed 30 psi of pressure.

Technician II says that you should keep your hands free from oil and grease.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____8. Technician I says that you should not run a vehicle in a shop unless the vehicle's exhaust is ventilated outside.

Technician II says that carbon monoxide can kill you.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____9. Technician I says you should disconnect the current-supply wire from a fan motor on a transverse mounted engine before doing any work in the area of the fan.

Technician II says that if you disconnect the current-supply wire on a fan motor you could burn out the fan motor.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____10. Technician I says you should disconnect the starting battery as soon as any car is brought into the shop.

Technician II says some on-board computer systems can be damaged if the battery is incorrectly disconnected.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

(NOTE: Completion of this portion of the unit test is the evaluation for Compentency D2 "Identify General Safety Rules." Of the 10 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this portion of the test.)

PART II–CHEMICAL SAFETY

I. Select the best answer from the choices listed.

_____11. When cleaning up flammable liquids, always dispose of the rags in: (a) an approved container, (b) an open trash barrel, (c) a dumpster, (d) an unused corner of the building, (e) the rag bag.

_____12. When pumping a flammable liquid from a large container into a small one, be sure to first attach a bond and ground wires to prevent: (a) the liquid from spilling, (b) spontaneous combustion, (c) a spark, (d) the nozzle from clogging, (e) the liquid from spilling on you.

_____13. Asbestos particles can cause cancer and they are found in: (a) paint materials, (b) clutch parts and brake shoes, (c) air compressor filters, (d) frame-straightening equipment, (e) grinding disks.

_____14. Paints and thinners should always be kept: (a) in large tanks, (b) in closed containers, (c) in glass containers, (d) near the work stations, (e) none of the above.

_____15. You should never overload electrical circuits, but you must be especially careful of overloading electrical circuits in: (a) the office, (b) the paint room, (c) the paint storage area, (d) the welding area, (e) b and c.

_____16. Paint products can cause which of the following: (a) headaches, (b) stomach aches, (c) blindness, (d) death, (e) all of the above.

_____17. The dust from sanding or grinding on plastic filler is harmful if it: (a) is epoxy-type filler, (b) is enamel-type filler, (c) gets on your skin, (d) gets in your lungs, (e) all of the above.

_____18. When using fiberglass filler, the materials can cause which of the following: (a) blindness, (b) skin irritation, (c) a fire, (d) respiratory illness, (e) all of the above.

_____19. The solution in vehicle batteries which can cause skin injuries and eye injuries is: (a) electrolyte, (b) an acid, (c) a base, (d) a and b, (e) a and c.

_____20. Safety is extremely important in working with air conditioning systems because the refrigerant inside is: (a) flammable, (b) hazardous if inhaled, (c) hazardous if it contacts the eyes, (d) hazardous if burning fumes are inhaled, (e) all of the above.

(NOTE: Completion of this portion of the unit test is the evaluation for Competency D5 "Use chemicals safely." Of the 10 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this portion of the test.)

PART III--USE PROTECTIVE CLOTHING AND EQUIPMENT

I. Select the best answer from the choices listed.

_____21. Technician I says that whenever you are in the shop you should wear your safety glasses.

Technician II says that whenever you are in the shop you should wear your particle mask.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____22. Technician I says that when working with brake shoes and clutches in the shop you should always wear safety glasses.

Technician II says that when working with brake shoes and clutches in the shop you should always wear a particle mask.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____23. Technician I says that when carrying vehicle glass you should wear safety glasses.

Technician II says that when carrying vehicle glass you should wear heavy gloves.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____24. Technician I says that when mixing paint materials you should wear rubber gloves.

Technician II says that when mixing paint materials you should wear an air supply respirator.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____25. Technician I says that when sanding paint you should wear rubber gloves.

Technician II says that when sanding paint you should wear a particle mask.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____26. Technician I says that when spraying non-toxic paint materials you should wear rubber gloves.

Technician II says that when spraying non-toxic paint materials you should wear a filter respirator and safety goggles.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____27. Technician I says that when spraying paint containing isocyanates you should wear safety goggles and rubber gloves.

Technician II says that when spraying paint containing isocyanates you should wear an air supply respirator.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____28. Technician I says that when sanding or grinding plastic filler you should wear heavy gloves.

Technician II says that when sanding or grinding plastic filler you should wear a face shield.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____29. Technician I says that when mixing fiberglass resin you should wear rubber gloves and safety glasses.

Technician II says that when mixing fiberglass resin you should wear a filter respirator.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____30. Technician I says that when grinding or sanding fiberglass filler you should wear safety glasses, heavy gloves, a face shield and a respirator.

Technician II says that when grinding or sanding fiberglass filler you should wear safety goggles, rubber gloves, a face shield and a particle mask.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____31. Technician I says that when working with air conditioning systems you should wear safety goggles.

Technician II says that when working with air conditioning systems you should wear rubber gloves.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____32. Technician I says that when using a bench grinder you should wear safety glasses and heavy gloves.

Technician II says that when grinding metal with a disk grinder you should wear safety glasses, a face shield and heavy gloves.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

____33. Technician I says when using an oxyacetylene welder you should wear safety goggles and welding gloves.

Technician II says that when using a MIG welder you should wear a welding helmet and an air supply respirator.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

(NOTE: Completion of this portion of the unit test is the evaluation for Competency D3 "Use protective clothing and equipment." Of the 13 questions, a score of ____ correct = 3, ____ correct = 2, ____ correct = 1, ____ correct or below = student should re-take this portion of the test.)

PART IV—IDENTIFY THE PROPER USE OF FIRE PROTECTION EQUIPMENT

I. Select the best answer from the choices listed.

____34. Technician I says that if gasoline catches on fire you should put it out with a class A fire extinguisher.

Technician II says that if gasoline catches on fire you should put it out with a class D fire extinguisher.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

____35. Technician I says that if magnesium catches on fire you should put it out with a class A fire extinguisher.

Technician II says that if magnesium catches on fire you should put it out with a class D fire extinguisher.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

____36. Technician I says that if you have a class ABC fire extinguisher you can put out any type of fire with it.

Technician II says that a class ABC fire extinguisher cannot put out a plastic fire.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

____37. Technician I says that if oily rags have caught on fire you should attempt to smother them with a fire blanket.

Technician II says that if oily rags have caught on fire you should use a class ABC fire extinguisher on them.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____38. Technician I says that if motor oil catches on fire you can use either a class ABC or a class BC fire extinguisher on it.

Technician II says that if motor oil catches on fire you should put it out with a class D fire extinguisher.

Who is right?
A. I only
B. II only
C. Both I and II
D. Neither I nor II

_____39. Technician I says that a fire blanket is used to throw over a fire and smother it.

Technician II says that a fire blanket is used to carry injured people to safety.

Who is right?
A. I only
B. II only
C. Both I and II
D. Neither I nor II

_____40. Technician I says that a class A fire extinguisher will only put out wood or cloth fires.

Technician II says that a pump tank fire extinguisher will only put out burning liquids.

Who is right?
A. I only
B. II only
C. Both I and II
D. Neither I nor II

_____41. Technician I says that a class BC fire extinguisher will not work on a wood or clothing fire.

Technician II says that a class BC fire extinguisher will not work on burning metals.

Who is right?
A. I only
B. II only
C. Both I and II
D. Neither I nor II

_____42. Technician I says that a class D fire extinguisher will only put out burning metals

Technician II says that a class D fire extinguisher will put out anything except burning metals.

Who is right?
A. I only
B. II only
C. Both I and II
D. Neither I nor II

_____43. Technician I says that a class BC fire extinguisher contains only water.

Technician II says that a multipurpose dry chemical fire extinguisher is for class A and B and C fires.

Who is right?
A. I only
B. II only
C. Both I and II
D. Neither I nor II

(NOTE: Completion of this portion of the unit test is the evaluation for Competency D4 "Identify the proper use of fire protection equipment." Of the 10 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below = student should re-take this portion of the test.)

PART V—IDENTIFY GOVERNMENT AGENCIES REGULATING THE AUTO BODY INDUSTRY

I. Select the best answer from among the five choices listed.

_____44. OSHA is a federal agency which issues guidelines concerning: (a) the safety of fire extinguishers, (b) the safety of the environment, (c) the safety of vehicles, (d) the safety of the worker, (e) none of the above.

_____45. EPA is a federal agency which issues guidelines concerning: (a) the safety of fire extinguishers, (b) the safety of the environment, (c) the safety of vehicles, (d) the safety of the worker, (e) none of the above.

_____46. OSHA is a federal agency which issues guidelines concerning: (a) the correct labeling of hazardous components of equipment, (b) the correct storage of equipment and materials, (c) the use of protective clothing and equipment, (d) the placement of warning and safety signs, (e) all of the above.

_____47. EPA is a federal agency which issues guidelines concerning: (a) the correct labeling of hazardous components, (b) the use of seat belts, (c) the environment, (d) the placement of warning and safety signs, (e) all of the above.

(NOTE: Completion of this portion of the unit test is the evaluation for Competency D1 "Identify government agencies regulating the auto body industry." Of the 4 questions, a score of _____ correct = 3, _____ correct = 2, ____ correct = 1, _____ correct or below = student should re-take this portion of the test.)

ANSWERS TO UNIT VI TEST

PART I.

1. C
2. B
3. B
4. D
5. B
6. B
7. B
8. C
9. A
10. C

PART II.

11. A
12. C
13. B
14. B
15. E
16. E
17. D
18. E
19. D
20. E

PART III.

21. A
22. C
23. C
24. A
25. D
26. C
27. C
28. D
29. D
30. A
31. A
32. C
33. D

PART IV.

34. D
35. B
36. D
37. B
38. A
39. D
40. A
41. C
42. A
43. C

PART V.

44. D
45. B
46. E
47. C

MODULE: INTRODUCTION TO AUTO BODY

UNIT VII: ESTIMATING

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to write a damage report in logical sequence. Mastery will be evidenced through demonstration and by scoring ______ percent on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Identify principles of estimating (Competencies E1, E2, E3, Unit VII test)

II. Identify principles of making the written estimate (Competencies E1, E2, E3, Unit VII test)

III. Identify principles of using collision manuals (Competencies E1, E2, E3, Unit VII test)

IV. Demonstrate the ability to:

  a. Diagnose and analyze damage (Competency E1, Assignment Sheet #1)

  b. Use collision manuals (Competency E2, Assignment Sheet #2)

  c. Write a damage report in logical sequence (Competency E3, Assignment Sheet #3)

MODULE: INTRODUCTION TO AUTO BODY

UNIT VII: ESTIMATING

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

  1. Lesson 1: Analyze Damage and Write a Damage Report

    a. Information outline

    b. Handouts

      HO#1: Collision manual page
      HO#2: Estimating form

    c. Assignment sheets

      AS#1: Diagnose and analyze damage
      AS#2: Use collision manuals
      AS#3: Write a damage report in logical sequence

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Demonstrate the use of the I-CAR zone system, or a comparable system, for analyzing collision damage.

B. Show students examples of damage reports.

C. Each student should use the assignment sheets in this unit to evaluate the damage to each vehicle brought into the shop. As the student nears the end of the complete auto body program the assignment sheets should be used to evaluate competencies E1 and E3. The instructor will have to determine the guidelines for the student's evaluation on the competency using the guidelines on the competency profile where 3 = Mastered, 2 = Can perform job completely with limited supervision, 1 = Requires instruction and close supervision.

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MODULE: INTRODUCTION TO AUTO BODY

UNIT VII: ESTIMATING

LESSON ONE: ANALYZE DAMAGE AND WRITE A DAMAGE REPORT

I. **Principles of estimating**

A. Operating a body shop profitably is not possible unless the body shop has personnel who can examine a damaged vehicle and tell what must be repaired and how much it will cost.

B. The auto body business is highly competitive and in order to gain work, the body shop must be able to tell customers, in most cases, exactly how much it will cost to fix their vehicles.

C. Although there are sometimes adjustments made in estimates, a body shop's estimates must be reasonably accurate and reasonably priced.

D. Insurance companies employ their own adjusters and/or estimators, who also examine vehicles and give their own estimate or make adjustments in the shop's estimate.

E. In some cases, a disagreement arises between the insurance adjuster and the body repair shop over the cost of a repair job.

F. To avoid frustrating and costly battles with insurance adjusters, it is a matter of great importance to be able to examine a damaged vehicle accurately, determine the extent of damage, and then to be able to competently fix *all the damage* at a competitive price.

G. Although the customer may not be required by the insurance company to go to the shop with the lowest bid, no shop can stay in business long unless their bids are very competitive with other shops.

H. There are different types of estimates

1. A *competitive estimate* is the most important one. It is essentially a "bid," telling the customer or insurance company that you will fix the damage for the price quoted on the estimate.

2. A *prospective estimate* is an estimate in which a customer is considering having some work done and is asking how much it will cost to do it. Since no insurance is involved, the customer will be choosy, but there also can be negotiations.

3. A *courtesy estimate* is one in which the customer needs several estimates and is asking you to make one, even though the customer may select another shop regardless of your quote. A courtesy estimate may also be requested by an insurance company in a case where the vehicle is a total loss and they wish to have an estimate for a settlement, even though the vehicle will not be repaired.

I. There are three important factors in estimating damage

1. Understanding vehicle construction

2. Understanding primary and secondary damage

3. Understanding collision manuals

J. Vehicle construction

1. The construction of vehicles varies widely with the make and model of the vehicle.

2. Although some components are common to all vehicles, there are many components which are made in radically different ways. This is particularly true of body panels, which will always be involved in collision repair.

3. In estimating repair costs, the estimator must know what panels that can be seen are damaged and also what hidden panels are likely to be damaged.

K. Primary and secondary damage

1. In every collision there is primary damage.

    a. Primary damage results from the direct impact of the collision. Areas of primary damage came into contact with what the vehicle struck.

    b. Primary damage is almost always obvious.

2. In most collisions there is secondary damage in addition to primary damage.

    a. Secondary damage results from primary damage.

    b. As the panels and components damaged by primary damage buckle, tear or break, the stresses the primary damage causes to the vehicle may cause extensive secondary damage.

    c. Secondary damage may not be evident without a close inspection.

L. Collision manuals

1. In order to speed estimating, body shops use collision manuals.

2. Collision manuals show the location of vehicle parts, the cost of replacement parts, and the estimated installation or repair time.

3. In using collision manuals, one important consideration is to figure overlap time in calculating the time needed to make repairs. For example, the collision manual may show a time of 3.5 hours needed to remove and replace a front fascia assembly, and a time of 1.5 hours to replace the bumper. But if both are being repaired there will be a savings of time because the estimate for removing and replacing the front fascia also includes the time needed to remove and replace the bumper.

II. The written estimate

A. The written estimate should be made in a logical sequence, following the format of collision manuals.

B. Items to be listed include all damaged parts, the cost of replacement parts, labor and materials involved, and such things as whether new or used parts will be used and whether an item will be sublet.

C. The written estimate is considered by the insurance company to be a firm statement of what the job involves and at what price.

D. In order to avoid losing money on damage that cannot be seen until some damaged areas are removed, the estimator may leave some parts of the estimate open.

E. To leave an item open the item must be listed, followed by a price total marked "open." This is done in cases where there may be damage, but the presence of damage or the extent of damage cannot be known until other components are removed.

F. An important part of making an estimate on a vehicle with extensive damage is to determine if the vehicle can be economically repaired.

   1. If the cost of repairing the vehicle exceeds the value of the vehicle, the vehicle is "totaled."

   2. If the vehicle is totaled, then the insurance company will not pay to have it fixed with new parts. Therefore a good estimator will begin to consider the use of recycled parts. By writing an estimate involving recycled parts, a totaled vehicle can sometimes be repaired, provided the insurance company can convince the owner of the vehicle to a repair with recycled parts.

G. In using recycled parts it is up to the insurance company to negotiate with the vehicle owner concerning the use of recycled parts.

   1. Although the vehicle owner may not agree to the use of recycled parts, a shop owner is wise to try to write estimates with recycled parts, when warranted. In some cases the vehicle owner will agree to recycled parts and the shop will have created work for itself.

   2. In writing an estimate with recycled parts, the estimator must know if recycled parts are available and what their cost will be.

H. There are three steps in making an estimate.

   1. Analyzing damage

   2. Using collision manuals

   3. Writing a damage report in a logical sequence

I. Analyzing damage

1. The Inter-Industry Conference on Auto Collision Repair (I-CAR) recommends a "Zone System" for analyzing damage.

2. The vehicle is divided into five zones.

3. Items within the five zones are listed on a checksheet, which is used in analyzing the extent of damage and the parts damaged.

J. The five zones in the I-CAR system

1. Primary damage – Panels and other major components damaged from direct contact.

2. Secondary damage – Damage to the vehicle panels and other major components in all areas outside area of primary damage.

3. Mechanical components – Damage to the engine, drive train and suspension.

4. Passenger compartment – Damage to components inside the passenger compartment.

5. Exterior Trim – Damage to trim and miscellaneous other exterior items, including bumper assemblies.

K. Equipment needed to analyze collision damage

1. Equipment to raise vehicle for underbody inspection

(**CAUTION:** *Do not attempt to lift a vehicle for analyzing damage until you have been properly instructed in lifting, jacking and supporting techniques outlined in Unit V, this module.)*

2. Tram gauge, steel tape and common hand tools.

(NOTE: See Module 7 "Frame-Body and Unibody Construction and Repair" for information on the tram gauge.)

3. Manufacturer's parts list and vehicle dimension specifications

4. Equipment to perform steering and suspension quick checks.

(NOTE: See Module 7 "Frame-Body and Unibody Construction and Repair" for performing steering and suspension quick-checks.)

L. Additional checks

1. Remember in measuring dimensions that a tolerance of three mm for unibody vehicles is the maximum allowed.

2. As you make checks, be sure to note whether repair or replacement will be necessary, and be sure to list refinishing procedures needed.

3. Start engine and operate power train, if possible.

4. Operate anything that opens, closes, turns, or moves in any way. On hood, door and deck openings, check opening gap size.

5. Don't inflict additional injury to the vehicle while checking it over.

M. General sequence of analyzing damage

1. Start with major cosmetic panels in the primary damage area that must be repaired or replaced.

2. Record all other cosmetic panels in the primary damage area, such as inner cosmetic panels.

3. Record any damage to structural panels.

4. Record other primary damage.

5. Record cosmetic panels with secondary damage.

6. Record secondary damage to structural panels.

7. Record other damaged components.

8. Record mechanical components damaged.

9. Record passenger compartment components damaged.

10. Record trim components damaged.

11. Although the above is used for analyzing damage, follow the front-to-back procedure of collision manuals in writing a damage report.

N. Notes on analyzing damage

1. The purpose of any damage analysis system is to keep you from overlooking damage. Don't worry about whether a borderline item should be considered primary or secondary damage, just be sure it is recorded as damage so the analysis and resulting estimate will be accurate.

2. Some parts are listed in more than one zone. They should be addressed at the time they are first noted.

3. As you check the vehicle over, remember to watch for the following:

   a. Broken welds

   b. Paint stress

   c. Damaged seam sealer

   d. Damaged suspension mounts

   e. Body dimensions out of tolerance

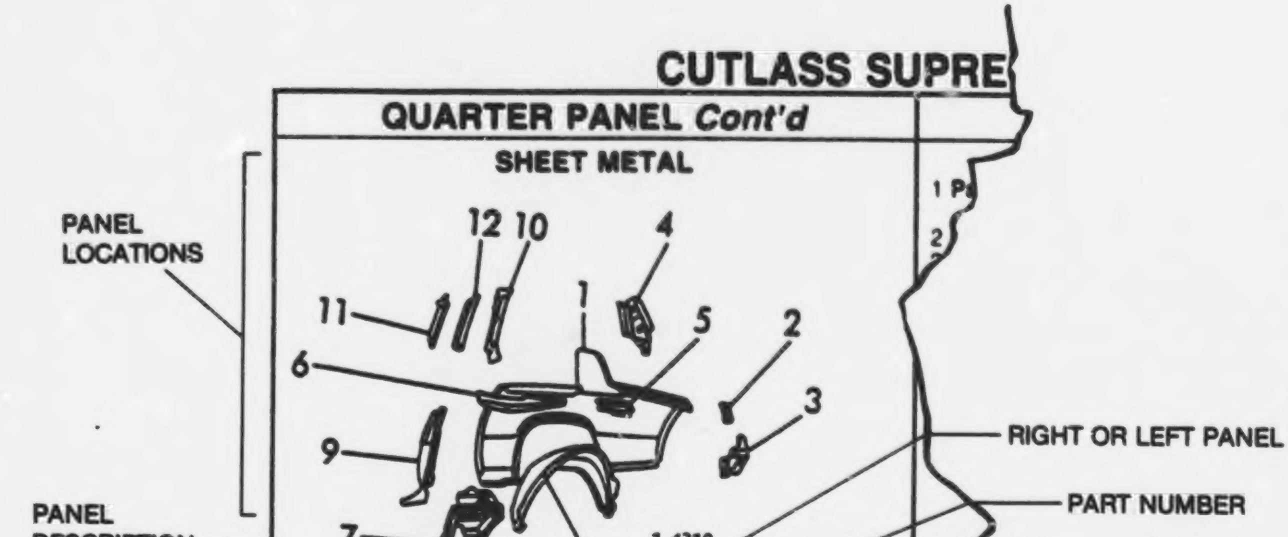
III. Collision manuals (FIG. 1-1)

A. Collision manuals are available from several sources.

B. When doing an estimate, beware of price increases. Use the latest manual available.

C. Multiply the hours estimated to do the job by your shop's labor rate.

D. The hours given for each job are estimates and must be modified due to extenuating circumstances, such as the need to cut away severely damaged sheet metal which is in the way of performing a repair operation.


PANEL LOCATIONS
PANEL DESCRIPTION
NOTES ON ADJUSTING LABOR HOURS
RIGHT OR LEFT PANEL
PART NUMBER
LABOR HOURS TO REPLACE
COST OF NEW PART
12
10
4
11
1
5
2
6
3
9
7
8
1-4210
1 Pa
2
1 Panel,
2 Pane
3 Pan
Lens
Hous
So
B

CUTLASS SUPRE

QUARTER PANEL *Cont'd*

SHEET METAL

1	**Panel, Outer**	R	*20607936	14.0	318.60
		L	*20607937	14.0	318.60
2	**Extension, Rear**		20495075-6	.5	23.85
3	**Extension, to Compt Pan**		20173872-3	#1.0	18.70
	#w/Quarter Panel Removed				
	Filler, Pan		20173880-1		16.05
4	**Panel, Inner Upper**		20173516-7		24.85
5	**Filler, at Quarter Window**		NA		
6	**Gutter, Otr Wind Drain**		NA		
	Stiffener, at Belt		20211842-3		4.85
7	**Panel, Inner Lower**		20211680-1		27.75
8	**Panel, Wheelhouse**	Outer	20173546-7	2.5	74.50
		Inner	20038540-1		44.00
9	**Pillar, Lock Lower¶**		NSS	#5.0	
	¶Included in Outer Panel				
	#Except w/Quarter Panel Removed 3.0				
	Panel, Pillar Upper				
10	**Inner**	exc	20337968-9		36.00
		w/Hatch Roof	20210718-9		45.50
11	**Outer**		NA		
12	**Extension, Upper Outer**		NA		

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E. Writing the damage report

1. Damage reports are also called estimates, but the term damage report is becoming more common because many body shops must now charge for making a report. Customers tend to feel anything called an "estimate" will be provided free.

2. A damage report should be written in a logical sequence, following the collision manual format.

3. In writing the estimate, be sure to record whether the part must be repaired or replaced. Skill and experience are the only factors in deciding if a panel should be repaired or replaced.

4. In totaling the estimate, be sure all figures are accurate and be sure you haven't overlooked anything.

   (NOTE: Insurance companies frown on reopening an estimate. Get everything right the first time, or if you are not sure of an item, record it as "left open.")

5. If damage is discovered that was left out of the estimate, the customer or the insurance company (whoever is paying) must be told immediately, before the work is done. A settlement will have to be reached with either the customer or the insurance company before the newly discovered damage can be repaired.

6. In addition to the cost of parts and labor, sales tax and sometimes a discount figure must be calculated.

7. Make sure all information on the customer is filled out at the top of the form and make sure a copy of the estimate is kept so it can be referred to if your shop gets the job. Also, make sure *all* information on vehicle type, style, etc. is recorded and *all* information on parts (color, special trim, etc.)

CUTLASS SUPREME/CALAIS (RWD) 1982-86

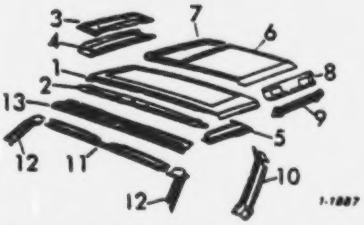
ROOF *Cont'd*

SUN ROOF *Cont'd*

¶Included in Housing Assembly

11 Retainer, Opening		20087830		114.00

HATCH ROOF



1 Panel - See Roof Panel				
2 Bow, Front		20006492		16.75
Bow, Longitudinal				
3 Upper		3069791		21.70
4 Lower		3078859		26.75
5 Rail, Side	R	20173466		31.75
	L	3073179		31.75
6 Glass Panel		20359056-7		541.00
7 Weatherstrip, Glass		20211820-1		53.75
8 Cover, Glass Support		20391736-7		9.05
9 Weatherstrip, Side		20217186-7		20.30
10 Panel, Lock Pillar		NA		
Frame, Windshield				
11 Upper		20087922		84.25
12 Side	R	20414887		147.00
	L	20373405		147.00
13 Reinf, Frame Upper		20064926		29.50
Moulding, Drip Scalp		20164422-3		26.00
Moulding, WS Pillar		20444640-1		47.75
Moulding, Windshield Frame Upper				
Front		20066038-9		20.10
Rear		20066040-1		34.25

BACK WINDOW

Glass, Back Window				
2 Door	Clear	20358210	#1.5	130.00
	NAGS	C B5741	#1.5	137.85
	Tinted	20358211	#1.5	142.00
	NAGS	T B5741	#1.5	140.05
	Heated	20358212	#1.7	269.00
	NAGS	T B5740	#1.7	278.40
4 Door Sedan	Clear	20146808	#1.5	133.00
	NAGS	C B6129	#1.5	135.00
	Tinted	20146809	#1.5	137.00
	NAGS	T B6129	#1.5	138.50
	Heated	20146810	#1.7	264.00
	NAGS	T B6128	#1.7	280.50
#w/Tucked Vinyl Top Add 3.5				
Moulding, Reveal				
2 Door	Upper	20481618		23.90
	Side	20481606-7		20.10
	Lower exc	20291222-3		22.15
	w/Full Vinyl Roof¶	2033900'		25.50
¶Paint to Match				
Coupe	Upper	20442309		23.90
	Side	20442314-3		22.15
	Lower	20442309		23.90
4 Door	Upper	20169561-2		18.55
	Side	20146814-5		22.90
	Lower	20146816		22.90
Moulding, Inside Garnish¶				
2 Door	Upper	20540414	.2	22.65
4 Door	Upper	20540588	.2	26.00
	Side R	20400068	.2	12.40
	L	20540599	.2	12.20
	Lower	20397047	.2	26.00

¶Paint to Match

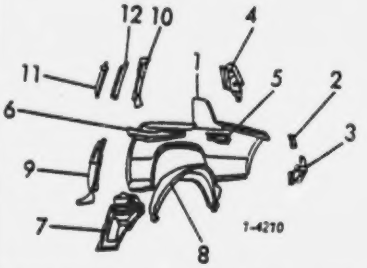
QUARTER PANEL

2 DOOR

Refinish Quarter Panel		2.8
Add for Pillar		.3
Add For Extension		.3
R&R Quarter Panel		
Section¶	R	11.5
	L	11.5
w/Roof Removed		8.5
Add to Quarter Panel R&R		
w/Vinyl Roof Cover		1.0
To Drill For & Install	One Mldg	.3
	Each Additional Mldg	.2

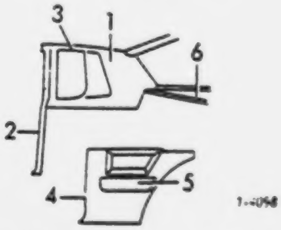
QUARTER PANEL *Cont'd*

SHEET METAL



1 Panel, Outer	R	*20607936	14.0	318.60
	L	*20607937	14.0	318.60
2 Extension, Rear		20495075-6	.5	23.85
3 Extension, to Compt Pan		20173872-3	#1.0	18.70
#w/Quarter Panel Removed				
Filler, Pan		20173880-1		16.05
4 Panel, Inner Upper		20173516-7		24.85
5 Filler, at Quarter Window		NA		
6 Gutter, Otr Wind Drain		NA		
Stiffener, at Belt		20211842-3		4.85
7 Panel, Inner Lower		20211680-1		27.75
8 Panel, Wheelhouse	Outer	20173546-7	2.5	74.50
	Inner	20038540-1		44.00
9 Pillar, Lock Lower¶		NSS	#5.0	
¶Included in Outer Panel				
#Except w/Quarter Panel Removed 3.0				
Panel, Pillar Upper				
10 Inner	exc	20337968-9		36.00
	w/Hatch Roof	20210718-9		45.50
11 Outer		NA		
12 Extension, Upper Outer		NA		

INTERIOR TRIM



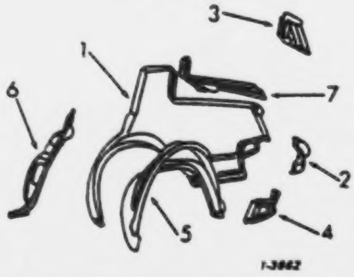
1 Panel, Trim Upper¶		20554800-1	80.50
2 Panel, Pillar Finish¶		20548764-5	14.10
3 Lace, Window Opng		NA	
4 Panel, Trim Lwr(a)	Vinyl	20227478-9	37.75
	Cloth/Vinyl	20312206-7	d36.75
5 Pad, Arm Rest¶		20545652-3	15.30
6 Panel, Package Tray¶		20546531	19.90

¶Paint to Match
(a)Order by Trim Code

4 DOOR SEDAN

Refinish Quarter Panel		2.5
Add for Pillar		.5
R&R Quarter Panel		
Section¶		10.5
¶Horizontal Cut at Belt In Window Opening		
Add to Quarter Panel R&R		
w/Vinyl Roof Cover exc		1.0
w/Tucked Vinyl		2.0
To Drill for & Install	One Mldg	.3
	Each Additonal Mldg	.2

SHEET METAL

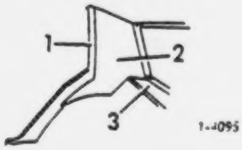


QUARTER PANEL *Cont'd*

SHEET METAL *Cont'd*

1 Panel, Outer	R	20265862	12.0	247.50
	L	20265863	12.0	247.50
2 Extension, Rear		20146806-7	.5	15.35
3 Extension, to Pan		20168594-5	#1.0	18.70
#w/Quarter Panel Removed				
4 Filler, to Pan		20016474-5		16.05
5 Panel, Whlhs	Outer	20006894-5	2.5	66.50
	Inner	20007001-2	2.0	44.00
6 Pillar, Lock		20225222-3	#5.0	68.00
#Except w/Quarter Panel Removed 3.0				
7 Gutter, Side		NSS		
¶Included in Outer Panel				

INTERIOR TRIM



1 Panel, Pillar Trim¶		20411394-5	11.95
2 Panel, Trim Upper¶	R	20180284	16.60
	L	20550385	13.70
3 Panel, Package Tray¶		20396668	15.60

¶Paint to Match

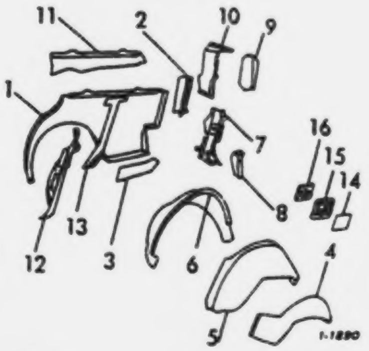
OPERA LAMP

Lens	5933912-1	10.15
Housing	5933884-3	22.25
Socket w/Cable	5933594	6.45
Bulb	9436790	1.95

WAGON

Refinish Quarter Panel	2.3
Add for Pillar	.5
Add to Quarter R&R	
To Drill for & Install	
One Moulding	.3
Each Additional Moulding	.2

SHEET METAL



1 Panel, Outer	R	*20006498	11.5	230.40
	L	*20006499	12.5	230.40
2 Extension, Rear		20115640-1		20.55
3 Filler, To Pan	R	20081870	1.0	32.50
	L	20006521	1.0	17.60
4 Bar, Upper Front	R	20006553		44.00
	L	20006554		70.25
Panel, Wheelhouse				
5 Inner	R	20006501	2.0	51.75
	L	20006502	2.0	79.00
6 Outer	R	20008428	2.5	70.00
	L	20008429	2.5	92.75
7 Pillar, Lower - See Rear Body				
8 Ext, at Bumper Cover		20024294-5		8.03
9 Pillar, Outer Upper - See Rear Body				
10 Pillar, Inner Uppur - See Rear Body				
11 Rail, Belt		20006518-9		17.15
12 Pillar, Lock Lower		20047137-8	#3.0	65.00
#w/Quarter Panel Removed				
13 Pillar, Inner Upper		20020365-6		35.25
14 Door, Fuel		20206699	.3	40.00
15 Filler, Fuel Door		20032868		14.00
16 Pocket, Filler		3064743		21.70

BEST COPY AVAILABLE

SCHOOL PAINT & BODY SHOP
0010 School Road
Phone 555-0000

Name	Address	Phone	Date

Year	Make	Model	License No.	Speedometer	Mtr. No. Ser. No.

Insurance	Adjuster	Phone	Car Located At

OPERATIONS	Part No.	Parts	Labor
	TOTALS		
	TAX		
	TOTAL OF ESTIMATE		

The above is an estimate, based on our inspection, and does not cover additional parts or labor which may be required after the work has been opened up. Occasionally, after work has started, worn, broken or damaged parts are discovered which are not evident on first inspection. Quotations on parts and labor are current and subject to change.

Estimate Made by ____________________

Signature ________________________________ Date ______________

ASSIGNMENT SHEET #1, LESSON ONE

ANALYZE DAMAGE

INSTRUCTIONS FOR STUDENT

1. Your instructor will direct you to use this form to diagnose and analyze damage to a vehicle brought into the shop.

2. Using a collision manual to assist you in locating panels, and the I-CAR zone system checklist (or comparable system), record the damage on the form below. Use a checkmark to show whether the item will be repaired or replaced.

DAMAGED ITEM	DESCRIPTION OF DAMAGE	REPAIR	REPLACE

ASSIGNMENT SHEET #2, LESSON ONE

USE COLLISION MANUALS

INSTRUCTIONS FOR STUDENT

1. Your instructor will direct you to use this form to record the parts and labor charges required to repair the vehicle analyzed in Assignment Sheet #1.

2. Using a collision manual to assist you, record the cost of parts and labor on the form below. Your instructor will inform you of the labor rate in figuring the labor cost.

DAMAGED ITEM	PART NUMBER	PART COST	LABOR HOURS	LABOR COST

ASSIGNMENT SHEET #3, LESSON ONE

WRITE A DAMAGE REPORT

INSTRUCTIONS FOR STUDENT:

1. Using a copy of Hand Out #2 (or another form approved by instructor), complete a damage report using the information complied in Assignment Sheet #1 and Assignment Sheet #2.

2. Your instructor will provide you with the information on the vehicle's owner and insurance company.

MODULE: INTRODUCTION TO AUTO BODY

UNIT VII: ESTIMATING

UNIT VII TEST

I. Select the best answer from the choices listed.

____1. Estimator I says that writing an estimate is not particularly important since the insurance company will write its own estimate.

Estimator II says that an estimate will always need adjustments as the vehicle is actually fixed and you don't need to worry about leaving an item off of the estimate.

Who is right?
A. I only
B. II only
C. Both I and II
D. Neither I nor II

____2. Estimator I says that secondary damage is damage that was caused as a result of primary damage.

Estimator II says that secondary damage is damage that was a result of the vehicle being towed into the shop.

Who is right?
A. I only
B. II only
C. Both I and II
D. Neither I nor II

____3. Estimator I says that overlap time is a result of one technician performing the same operation as another technician.

Estimator II says that figures for overlap time can usually be found in the collision manual.

Who is right?
A. I only
B. II only
C. Both I and II
D. Neither I nor II

____4. Estimator I says that if the cost of repairing the vehicle with new parts exceeds the value of the vehicle the estimator should not waste time with an estimate.

Estimator II says that if the cost of repairing the vehicle with new parts exceeds the value of the vehicle the estimator should consider writing an estimate to repair the vehicle with recycled parts.

Who is right?
A. I only
B. II only
C. Both I and II
D. Neither I nor II

____5. Estimator I says that the written estimate should be made in a sequence that follows the format of collision manuals.

Estimator II says that the written estimate should be made in a sequence that follows the I-CAR zone system for damage analysis.

Who is right?
A. I only
B. II only
C. Both I and II
D. Neither I nor II

II. Use the portion of the collision manual on the following page of the test to answer the questions on this page. All of the information needed is on the page from the collision manual. For each question, select the best answer from the choices given.

_____6. How many hours should it take to refinish a quarter panel on a 4-door sedan (no pillar involved)? (a) 2.5, (b) 2.8, (c) 3, (d) 12, (e) 12.5.

_____7. How many hours should it take to remove and replace a quarter panel section (with horizontal cut at belt line) on a 4-door sedan, if no vinyl top is involved and you have to drill holdes for two moldings. (a) 10.5, (b) 11, (c) 11.5, (d) 12, (e) 12.5.

_____8. How many hours should it take to remove and replace a lower lock pillar on a two-door if the quarter panel has not been removed? (a) 1, (b) 2.5, (c) 3, (d) 3.5, (e) 5.

_____9. How many hours should it take to remove and replace a tinted back window glass in a 2-door which has a tucked vinyl top? (a) 1.5, (b) 1.7, (c) 3.5, (d) 5, (e) 5.2.

_____10. How many hours should it take to remove and replace a complete right quarter panel (outer), along with the lock pillar, the side gutter and the extension (to pan) on a 4-door sedan. (a) 13, (b) 14.5, (c) 15.5, (d) 16, (e) 18.

_____11. What is the part number of the right quarter panel (outer) on a 4-door sedan? (a) 20265862, (b) 20265863, (c) 20554800-1, (d) 20607936, (e) 20607937.

_____12. What is the part number of the upper back window reveal molding on a 4-door? (a) none shown, (b) 20169561-2, (c) 201481618, (d) 20545652-3, (e) 3064743.

_____13. What is the cost of the fuel door on the quarter panel of a wagon? (a) $14, (b) $20.55, (c) $24.85, (d) $40, (e) $70.25.

_____14. Estimator I says that the package tray panel is the same part on the 4-door as on the two-door.

Estimator II says that the quarter panel (outer) on the two-door is more expensive that the quarter panel (outer) on the four-door.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

_____15. Estimator I says on a two-door that removing and replacing the complete left quarter panel and the lower lock pillar, plus refinishing both parts would take 20.1 hours.

Estimator II says that the if the labor rate is $20 per hour, the cost of doing the job described by Technician I (excluding tax) would be $720.60.

Who is right? A. I only B. II only
C. Both I and II D. Neither I nor II

(NOTE: Successful completion of this unit test with a minimum score of ____ is necessary for the student to receive an evaluation on Competencies E1, E2, E3.)

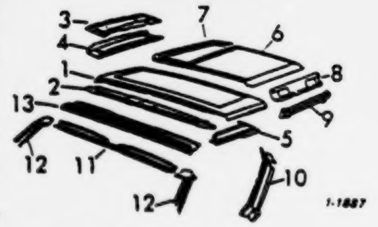
ROOF *Cont'd*

SUN ROOF *Cont'd*

¶Included in Housing Assembly

Retainer, Opening		20087830		114.00

HATCH ROOF



1 **Panel - See Roof Panel**			
2 **Bow, Front**		20006492	16.75
Bow, Longitudinal			
3 Upper		3069791	21.70
4 Lower		3078859	26.75
5 **Rail, Side**	R	20173466	31.75
	L	3073179	31.75
6 **Glass Panel**		20359056-7	541.00
7 **Weatherstrip, Glass**		20211820-1	53.75
8 **Cover, Glass Support**		20391736-7	9.05
9 **Weatherstrip, Side**		20217186-7	20.30
10 **Panel, Lock Pillar**		NA	
Frame, Windshield			
11 Upper		20087922	84.25
12 Side	R	20414887	147.00
	L	20373405	147.00
13 **Reinf, Frame Upper**		20064926	29.50
Moulding, Drip Scalp		20164422-3	26.00
Moulding, WS Pillar		20444640-1	47.75
Moulding, Windshield Frame Upper			
Front		20066038-9	20.10
Rear		20066040-1	34.25

BACK WINDOW

Glass, Back Window				
2 Door	Clear	20358210	#1.5	130.00
	NAGS	C B5741	#1.5	137.85
	Tinted	20358211	#1.5	142.00
	NAGS	T B5741	#1.5	140.05
	Heated	20358212	#1.7	269.00
	NAGS	T B5740	#1.7	278.40
4 Door Sedan	Clear	20146808	#1.5	133.00
	NAGS	C B6129	#1.5	135.00
	Tinted	20146809	#1.5	137.00
	NAGS	T B6129	#1.5	138.50
	Heated	20146810	#1.7	264.00
	NAGS	T B6128	#1.7	280.50
#w/Tucked Vinyl Top Add 3.5				
Moulding, Reveal				
2 Door	Upper	20481618		23.90
	Side	20481606-7		20.10
	Lower exc	20291222-3		22.15
	w/Full Vinyl Roof¶	2033900*		25.50
¶Paint to Match				
Coupe	Upper	20442309		23.90
	Side	20442314-3		22.15
	Lower	20442309		23.90
4 Door	Upper	20169561-2		18.55
	Side	20146814-5		22.90
	Lower	20146816		22.90
Moulding, Inside Garnish¶				
2 Door	Upper	20540414	.2	22.65
4 Door	Upper	20540588	.2	26.00
	Side R	20400068	.2	12.40
	L	20540599	.2	12.20
	Lower	20397047	.2	26.00
¶Paint to Match				

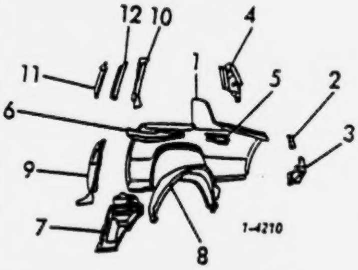
QUARTER PANEL

2 DOOR

Refinish Quarter Panel		2.8
Add for Pillar		.3
Add For Extension		.3
R&R Quarter Panel Section¶	R	11.5
	L	11.5
w/Roof Removed		8.5
Add to Quarter Panel R&R		
w/Vinyl Roof Cover		1.0
To Drill For & Install	One Midg	.3
	Each Additional Midg	.2

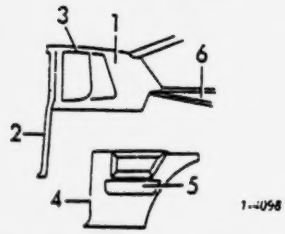
QUARTER PANEL *Cont'd*

SHEET METAL



1 **Panel, Outer**	R	*20607936	14.0	318.60
	L	*20607937	14.0	318.60
2 **Extension, Rear**		20495075-6	.5	23.85
3 **Extension, to Compt Pan**		20173872-3	#1.0	18.70
#w/Quarter Panel Removed				
Filler, Pan		20173880-1		16.05
4 **Panel, Inner Upper**		20173516-7		24.85
5 **Filler, at Quarter Window**		NA		
6 **Gutter, Qtr Wind Drain**		NA		
Stiffener, at Belt		20211842-3		4.85
7 **Panel, Inner Lower**		20211680-1		27.75
8 **Panel, Wheelhouse**	Outer	20173546-7	2.5	74.50
	Inner	20038540-1		44.00
9 **Pillar, Lock Lower¶**		NSS	#5.0	
¶Included in Outer Panel				
#Except w/Quarter Panel Removed 3.0				
Panel, Pillar Upper				
10 Inner	exc	20337968-9		36.00
	w/Hatch Roof	20210718-9		45.50
11 Outer		NA		
12 **Extension, Upper Outer**		NA		

INTERIOR TRIM

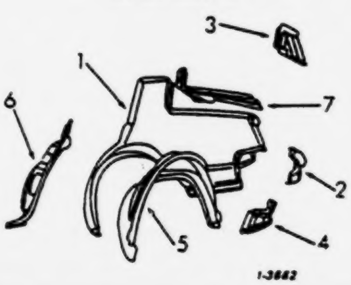


1 **Panel, Trim Upper¶**		20554800-1	80.50
2 **Panel, Pillar Finish¶**		20548764-5	14.10
3 **Lace, Window Opng**		NA	
4 **Panel, Trim Lwr(a)**	Vinyl	20227478-9	37.75
	Cloth/Vinyl	20312206-7	d36.75
5 **Pad, Arm Rest¶**		20545652-3	15.30
6 **Panel, Package Tray¶**		20546531	19.90
¶Paint to Match			
(a)Order by Trim Code			

4 DOOR SEDAN

Refinish Quarter Panel		2.5
Add for Pillar		.5
R&R Quarter Panel Section¶		10.5
¶Horizontal Cut at Belt In Window Opening		
Add to Quarter Panel R&R		
w/Vinyl Roof Cover exc		1.0
w/Tucked Vinyl		2.0
To Drill for & Install	One Midg	.3
	Each Additional Midg	.2

SHEET METAL

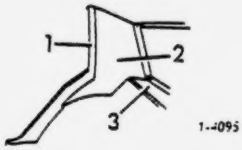


QUARTER PANEL *Cont'd*

SHEET METAL *Cont'd*

1 **Panel, Outer**	R	20265862	12.0	247.50
	L	20265863	12.0	247.50
2 **Extension, Rear**		20146806-7	.5	15.35
3 **Extension, to Pan**		20168594-5	#1.0	18.70
#w/Quarter Panel Removed				
4 **Filler, to Pan**		20016474-5		16.05
5 **Panel, Whlhs**	Outer	20006894-5	2.5	66.50
	Inner	20007001-2	2.0	44.00
6 **Pillar, Lock**		20225222-3	#5.0	68.00
#Except w/Quarter Panel Removed 3.0				
7 **Gutter, Side**		NSS		
¶Included in Outer Panel				

INTERIOR TRIM



1 **Panel, Pillar Trim¶**		20411394-5	11.95
2 **Panel, Trim Upper¶**	R	20180284	16.60
	L	20550385	13.70
3 **Panel, Package Tray¶**		20396668	15.60
¶Paint to Match			

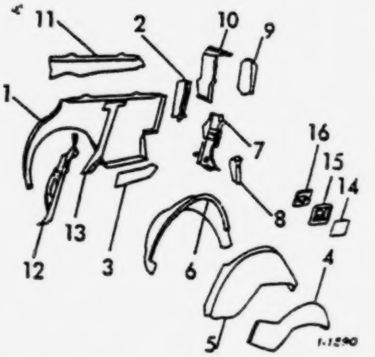
OPERA LAMP

Lens	5933912-1	10.15
Housing	5933884-3	22.25
Socket w/Cable	5933594	6.45
Bulb	9436790	1.95

WAGON

Refinish Quarter Panel	2.3
Add for Pillar	.5
Add to Quarter R&R	
To Drill for & Install	
One Moulding	.3
Each Additional Moulding	.2

SHEET METAL



1 **Panel, Outer**	R	*20006498	11.5	230.40
	L	*20006499	12.5	230.40
2 **Extension, Rear**		20115640-1		20.55
3 **Filler, To Pan**	R	20081870	1.0	32.50
	L	20006521	1.0	17.60
4 **Bar, Upper Front**	R	20006553		44.00
	L	20006554		70.25
Panel, Wheelhouse				
5 Inner	R	20006501	2.0	51.75
	L	20006502	2.0	79.00
6 Outer	R	20008428	2.5	70.00
	L	20008429	2.5	92.75
7 **Pillar, Lower - See Rear Body**				
8 **Ext, at Bumper Cover**		20024294-5		8.03
9 **Pillar, Outer Upper - See Rear Body**				
10 **Pillar, Inner Upper - See Rear Body**				
11 **Rail, Belt**		20006518-9		17.15
12 **Pillar, Lock Lower**		20047137-8	#3.0	65.00
#w/Quarter Panel Removed				
13 **Pillar, Inner Upper**		20020365-6		35.25
14 **Door, Fuel**		20206699	.3	40.00
15 **Filler, Fuel Door**		20032868		14.00
16 **Pocket, Filler**		3064743		21.70

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ANSWERS TO UNIT VII TEST

PART I.

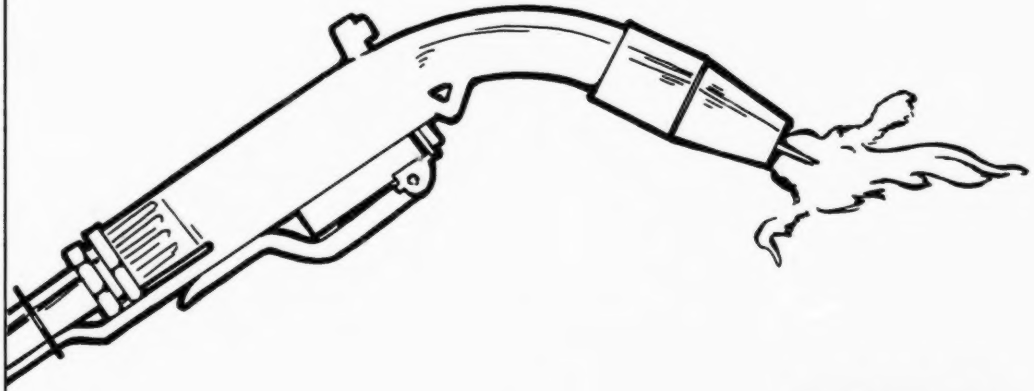
1. D
2. A
3. B
4. B
5. A

PART II.

6. A
7. B
8. E
9. D
10. D
11. A
12. B
13. D
14. B
15. C

Auto Body Repair Curriculum Guide

INSTRUCTOR'S GUIDE



MODULE 2:

- Welding Processes
- Safety
- Approved Auto Body Welds
- MIG Welding
- Oxyacetylene Welding
- Oxyacetylene Cutting

Auto Body Welding

Instructional Materials Laboratory • University of Missouri • Columbia, Missouri 65211 • 314/882-2883

AUTO BODY CURRICULUM
Instructor's guide

MODULE 2:
AUTO BODY WELDING

Written by Roger Helms

(Portions of Units I, II and III of this material were adapted
from *Gas Metal Arc Welding and Flux-cored Arc Welding*,
Mid-America Vocational Curriculum Consortium, Inc. 1984.
Portions of Units IV and V were adapted from *Auto Body Repair*,
Instructional Materials Laboratory, University of Missouri, 1977.)

Technical advisory committee:

Harold Harden, Gil Hardin, Alan Polley, Don Roberts

Produced by the Instructional Materials Laboratory
10 Industrial Education Building
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Columbia, MO 65211
314/882-2884
July 1988

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Unit IV: Oxyacetylene welding equipment and safety 91

Unit V: Oxyacetylene welding and cutting 149

Auto Body

Welding

Cross-Reference Table of Instructional Materials

Competency	Unit	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
F 1	I	1-I, 1-III	1	1			1-33	
F 2	I	2-I					34-54	
F 3	II	1-I, 1-IV	1	1		1-3	1-42	
F 4	II	1-I, 1-IV				4	1-42	
F 5	III	1-I				1-3	1-26	
F 6	III	1-I				1	1-26	
F 7	III	1-I				2	1-26	
F 8	III	1-I				3	1-26	
F 9	III	1-I				1-3	1-26	
F 10	IV	2-I	1-10			1, 2	40-54	
F 11	IV	1-I--1-V	1-4	1		1, 2	1-39	
	V	1-I--1-II	1, 2			1-4	1-20	
F 12	V	2-I	1-4			1-3	21-34	
F 13	I	2-I					1-33	
	IV	2-I	1-10				40-54	

MODULE: WELDING

UNIT I: AUTO BODY WELDING AND MIG WELDING

UNIT OBJECTIVE

Upon completion of this unit the student should be able to identify types of welding used in auto body repair, and identify MIG welding processes and MIG welding safety. Mastery will be evidenced by scoring _____% on the unit test and demonstrating safe practices whenever operating MIG equipment.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1: I. Match terms with their definitions (Competency F1, Part I of Unit I test)

II. Identify auto body welding processes (Competency F1, Part I of Unit I test)

III. Identify MIG welding equipment (Competency F1, Part I of Unit I test)

Lesson 2: I. Identify MIG welding safety and safety equipment (Competencies F2, F13, Part II of Unit I test)

MODULE: WELDING

UNIT I: AUTO BODY WELDING AND MIG WELDING

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

    1. Lesson 1: Auto body welding and MIG welding

        a. Information outline

        b. Handout

        HO#1: MIG welder components

        c. Transparency masters

        TM#1: MIG arc

    2. Lesson 2: MIG Welding Safety

        a. Information outline

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. MIG machines in your shop should be thoroughly demonstrated. Safety procedures should be thoroughly covered and demonstrated.

B. It is necessary for the student to receive an appropriately high evaluation on this unit test, as well as the Unit IV test, in order to receive an evaluation on Competency F13 "Use protective clothing and equipment."

REFERENCES USED IN WRITING THIS UNIT

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MODULE: WELDING

UNIT I: AUTO BODY WELDING AND MIG WELDING

LESSON ONE: ORIENTATION TO AUTO BODY WELDING AND MIG WELDING

I. **Terms and definitions**

A. Brazing – The melting of a brass rod to hold two pieces of metal together without fusing them together.

B. Consumable – Something which is designed to be used up. A way of defining electrode wires used in MIG.

C. Contaminants – Impurities formed from chemical reactions among base metals, flux, and electrodes, and usually present in fumes and vapors.

D. Deposition rate – The amount of filler metal placed into a weld in a given period of time.

E. GMAW – Gas metal arc welding. A type of welding in which an electrode wire is fed into the weld and a shielding gas is used to protect the weld from contamination. Commonly called MIG welding.

F. Inert – Having no active properties.

G. MIG – Metal inert gas. The first name used to define the process of welding with a continuous consumable electrode in the presence of a shielding gas. Still used in reference to GMAW, although reactive gases such as CO_2 are now used.

H. Oxyacetylene welding – The use of oxygen and acetylene to produce heat for fusion welding.

I. Oxygen displacement – A drop in the oxygen level in the breathing zone around a welding activity. Caused by any arc or flame.

J. Reactive – An element or gas with properties that will actively combine with other elements present in a base metal or a filler electrode at high temperature.

K. Resistance spot welding – The use of electrodes on each side of two pieces of metal to be joined such that the two pieces are fused together surface-to-surface.

L. Shielding gases – Inert gases such as argon or helium, or reactive gases such as CO_2, that are directed under pressure into a weld zone to protect it from contaminants.

M. TIG – Tungsten inert gas welding. Also known as GTAW (gas tungsten arc welding) and Heliarc welding. Process uses a welding rod clipped into a holder. Used on heavy metal, but has little application for auto body repair due to high heat dispersion.

N. Toxic hazards – Poisonous gases, fumes, and vapors produced by chemical reactions in certain welding processes.

O. Welding -- The use of heat to melt two or more pieces of metal together.

II. **Comparison of MIG to other welding processes**

A. Types of welding with applications to auto body repair

1. MIG (also know as GMAW)

a. Recommended method for modern vehicle repair

b. Easy to learn

c. Low heat dispersion is most important factor in recommending MIG welding.

2. Oxyacetylene welding

a. Still has limited applications for modern vehicle repair

b. High heat dispersion is most important factor outdating oxyacetylene welding.

(NOTE: Oxyacetylene welding is covered in detail in Units IV and V.)

3. Oxyacetylene brazing

a. Has very limited applications for modern vehicle repair

b. High heat dispersion and low strength of brazing are the most important factors outdating oxyacetylene brazing.

4. Oxyacetylene body soldering

a. Hardly ever used in modern body shops

b. Expensive and time-consuming

5. Resistance spot welding

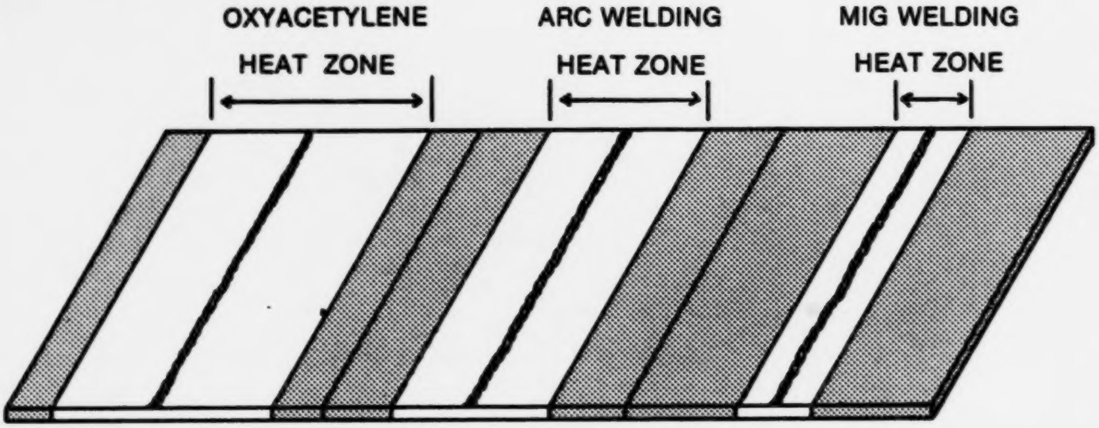
a. Not universally approved as method of repair for structural panels

b. Has applications for non-structural repair work

c. May eventually become important repair procedure as equipment and techniques improve

B. **Heat distortion caused by various welding processes. (FIG. 1-1)**

FIGURE 1-1



C. **Brief history of MIG welding**

1. The need for a welding process that could control heat in a small area led to the first patent for welding with consumable electrode welding equipment, in 1948.

2. Other developments led to the use of gas mixtures to provide a more stable welding arc.

3. The use of low-cost CO_2 as a shielding gas led to the expansion of the MIG process into automotive shops and other industries where less critical welding applications are demanded.

4. The introduction of high-strength steels and unibody construction in the auto body field gave emphasis to the MIG process because of its low heat dispersion.

5. As the MIG welding process was adapted to the auto body field, MIG machines were designed specifically for the auto body environment. These machines are less complex and easier to operate than other MIG welders.

D. **Advantages of the MIG process**

1. Beginners can be trained more quickly to weld with the MIG process than any other welding process.

2. Better control of heat at the weld zone reduces distortion in base metals.

3. Better welds are possible because the arc is always visible to the operator.

4. MIG is adaptable to both ferrous and nonferrous metals in all thicknesses, through modification of electrode wire and shielding gas selections.

5. Usually requires no clean-up and reduces welding costs

E. Limitations of the MIG process

1. Will not function in a windy environment

2. Requires careful setting of electrical components

III. **Principles of MIG (FIG. 1-2)**

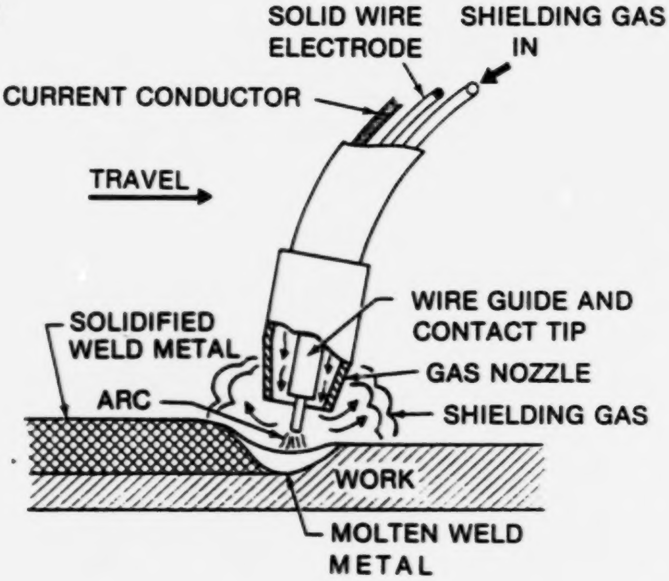
A. MIG welder operation

1. A bare electrode wire is fed through a wire feeder and cable assembly at a pre-set feed speed calibrated in inches per minute (ipm) to control the arc amperage in the weld zone, while voltage is controlled by a dial on the machine.

2. As the arc is struck, a shielding gas is forced around the electrode wire and the weld zone to stabilize the arc and protect the molten filler metal and base metal from contaminants.

3. Some welding units specifically designed for auto body have the voltage and electrode wire feed combined into one setting, eliminating the need for the operator to determine carefully the correct relationship between wire-feed speed and voltage.

FIGURE 1-2


SOLID WIRE ELECTRODE
SHIELDING GAS IN
CURRENT CONDUCTOR
TRAVEL
WIRE GUIDE AND CONTACT TIP
SOLIDIFIED WELD METAL
GAS NOZZLE
ARC
SHIELDING GAS
WORK
MOLTEN WELD METAL

Courtesy of Lincoln Electric Company

B. Benefits from learning MIG

1. Provides student with better visibility of the arc, electrode, and the total weld zone than does any other process

2. Provides student with an additional marketable skill

3. Provides an opportunity for profitable part-time self-employment

C. MIG and auto body

1. MIG is necessary for auto body repair due to the wide use of high-strength steels, which are damaged by excessive heat.

2. MIG is necessary to perform repairs on structural panels in unibody vehicles.

3. Additional advantages of MIG welding in auto body repair:

   a. Warping, distortion and metal fatigue are reduced.

   b. Uses no flames that can cause fire damage

   c. Ten times faster than brazing, and costs less

   d. MIG weld will grind flat without weakening the weld.

   e. Is four to five times faster than resistance spot welding

D. Special MIG equipment for the body shop

1. Requires a welder and cable assembly designed for the body shop environment

2. Usually uses C-25 gas containing 75% argon and 25% CO_2

3. Usually requires power supply of approximately 208 to 240 volts, although some units use 110-120 volts.

4. Although the MIG process is relatively easy to learn, and MIG machines for auto body repair have become simple to operate, it requires much practice because of the thin metals used in modern vehicle construction.

E. Effects of heat on metal

1. When heated, metal expands.

2. The greater the heat applied, the greater the expansion.

3. When heated, metal softens.

4. The greater the heat applied, the greater the softening until the metal melts.

5. The temperature at which metal melts is called the melting point.

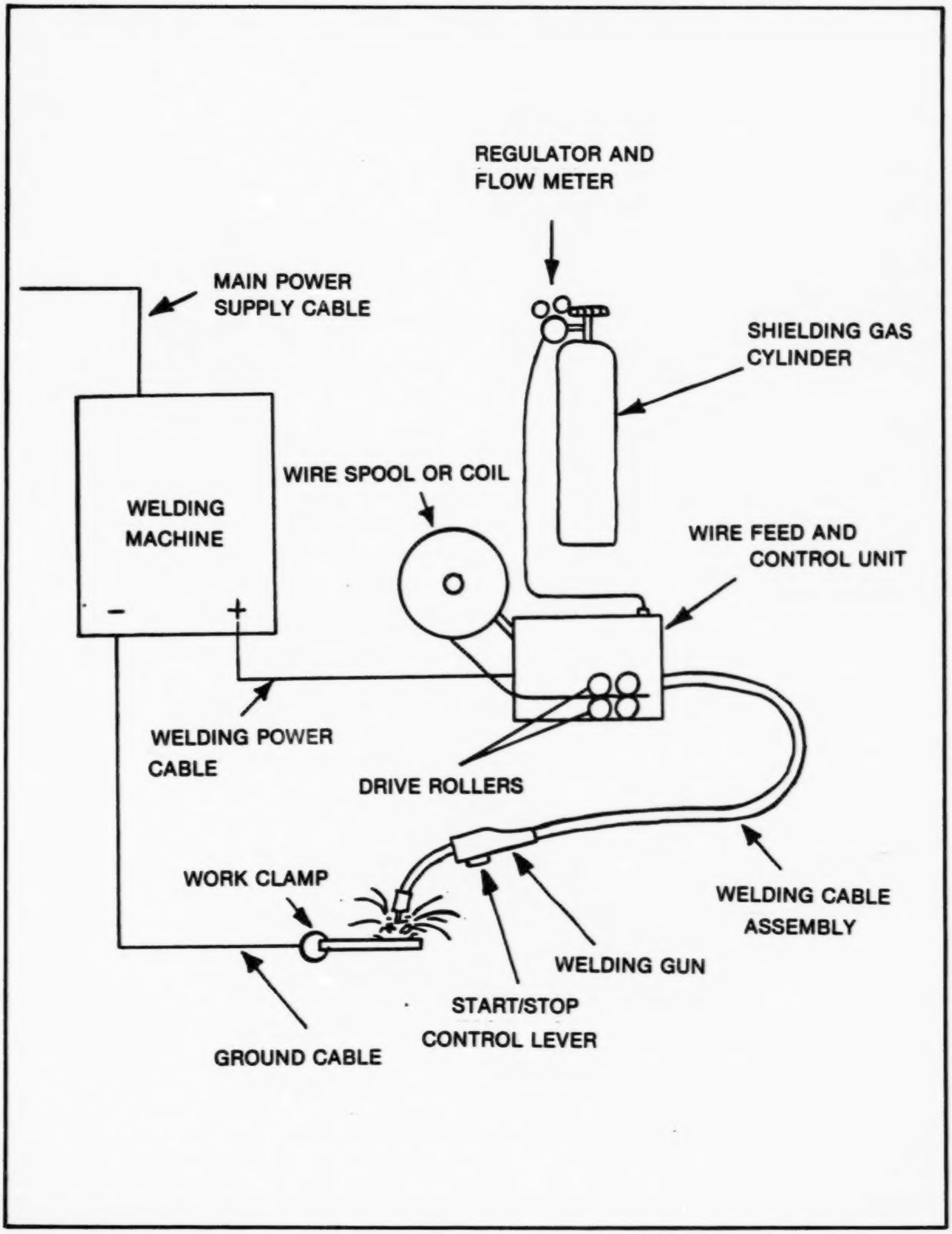
6. Melting point of various metals
   a. Aluminum -- 1220° to 1250° F.
   b. Brass -- 1615° to 1950° F.
   c. Copper -- 1840° to 1900° F.
   d. Mild steel -- 2500° to 2700° F.
   e. High-strength steel -- 2700° to 2900° F.

F. High-strength steels (HSS) and high-strength, low-alloy steels (HSLA)

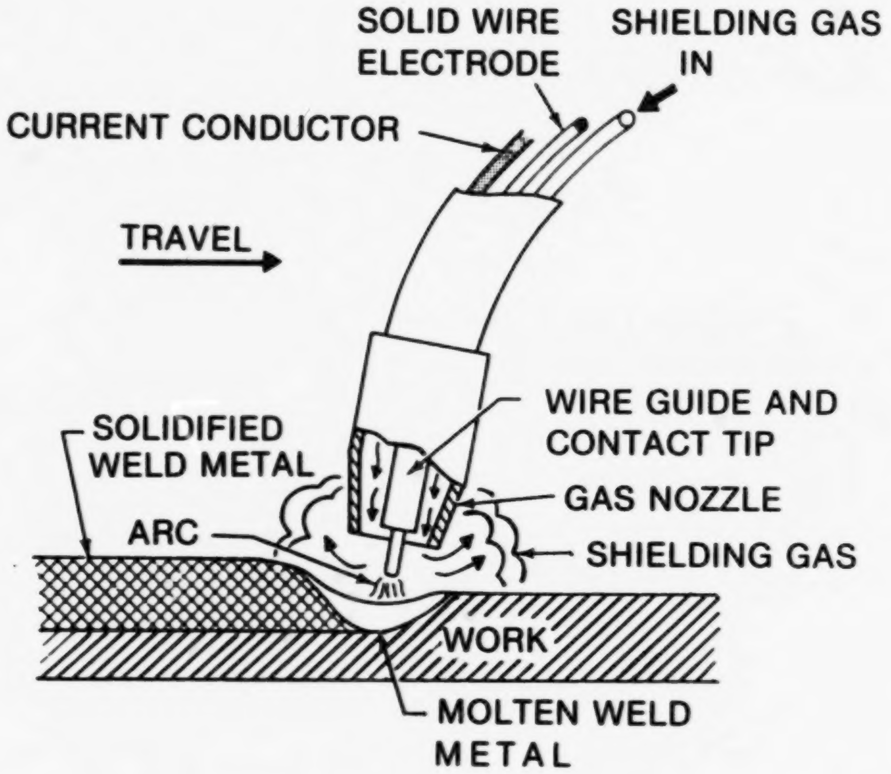
1. Used in most vehicles since 1980
2. Greater strength per weight, allowing thinner gauges to be used, thus reducing vehicle weight
3. Various compositions -- impossible to distinguish without vehicle manufacturer's service manual.
4. Cannot be heated beyond certain temperatures without greatly losing strength
5. Maintaining strength of HSS is critical because in unibody construction, each structural panel contributes to the structural integrity of the vehicle.
6. Some high-strength steels cannot be heated to more than 700° F. without losing strength. Some cannot be heated at all.
7. Since welding must produce temperatures hot enough to melt the metal, HSS and HSLA steels are damaged in the weld area.
8. In order to weld HSS and HSLA steels, only the weld area must reach the melting temperature -- adjacent areas must be protected from heat dispersion in the welding process.
9. MIG welding is done quickly enough that, when used with proper technique, it will not damage HSS or HSLA steel outside the weld area.

HO 1

MIG WELDER COMPONENTS


REGULATOR AND FLOW METER
MAIN POWER SUPPLY CABLE
SHIELDING GAS CYLINDER
WELDING MACHINE
-
+
WIRE SPOOL OR COIL
WIRE FEED AND CONTROL UNIT
WELDING POWER CABLE
DRIVE ROLLERS
WORK CLAMP
WELDING CABLE ASSEMBLY
WELDING GUN
START/STOP CONTROL LEVER
GROUND CABLE

MIG Welding Process


SOLID WIRE ELECTRODE
SHIELDING GAS IN
CURRENT CONDUCTOR
TRAVEL
WIRE GUIDE AND CONTACT TIP
SOLIDIFIED WELD METAL
GAS NOZZLE
ARC
SHIELDING GAS
WORK
MOLTEN WELD METAL

Courtesy of Lincoln Electric Company

MODULE: WELDING

UNIT I: AUTO BODY WELDING AND MIG WELDING

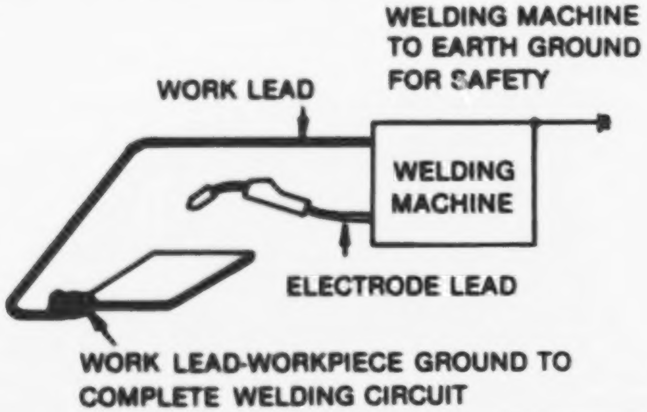
LESSON TWO: MIG WELDING SAFETY

I. **MIG welding safety**

A. MIG welding

1. All electrical equipment should have an earth ground for safety reasons, and this ground should not be confused with the work lead to workpiece ground that completes the welding circuit. (FIG. 2-1)

FIGURE 2-1


WELDING MACHINE TO EARTH GROUND FOR SAFETY
WORK LEAD
WELDING MACHINE
ELECTRODE LEAD
WORK LEAD-WORKPIECE GROUND TO COMPLETE WELDING CIRCUIT

2. Keep electrical connections tight, clean, and dry because poor connections can heat up, cause bad welds, produce dangerous arcs and sparking, and even melt.

3. Keep work area, equipment, and clothing dry because even a slight amount of moisture can conduct enough electricity to cause a severe shock.

4. Never dip a gun in water to cool it.

5. Keep welding cables as close as possible to the work area and do not connect cables to building framework because current can be directed through lifting chains and cables and weaken them.

B. Duty cycle safety

1. Duty cycle is used to avoid overheating and perhaps ruining a welding machine.

2. Duty cycle is based on a 10-minute period and the length of time during that period that a machine can be safely operated.

3. A machine with a 20% duty cycle could safely operate two minutes out of each 10-minute period. A 50% machine could operate five minutes out of each 10-minute period.

4. Use the National Electrical Manufacturers Association classification on the welding machine as a guideline to safe operation.
    a. Class I – Rated to deliver output at duty cycles of 60, 80, or 100 percent.
    b. Class II – Rated to deliver output at duty cycles of 30, 40, or 50 percent.
    c. Class III – Rated to deliver output at a duty cycle of 20 percent.

C. Important rules for handling cables and hoses

1. Never drag cables or hoses through dirt or oil, and never pull on a cable to force it over an obstruction.
2. Use clean, dry rags to clean cables and hoses. Do not use gasoline or an oily rag for the job.
3. Keep cables and hoses coiled, free of kinks and properly stored.
4. Never drape a welding cable over any type of gas cylinder, and *never* strike an arc on a gas cylinder.

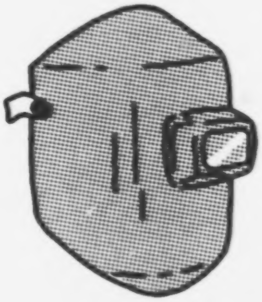
D. Arc ray hazards

1. A welding arc produces ultraviolet and infrared radiation that can severely burn eyes that are unprotected with a proper shade of protective lens.
2. Radiation from a welding arc can sunburn or blister bare skin if the exposure is intense or for an extended period.
3. Work areas should be shielded to prevent eye injuries to anyone nearby.

E. Types of welding hoods

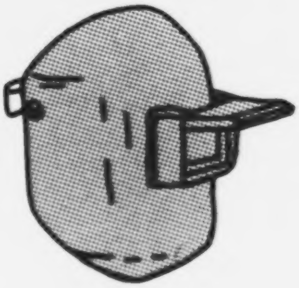
1. Stationary lens – This type of hood has a fixed lens. This hood flips up and out of the way when required. (FIG. 2-2)

FIGURE 2-2



2. Flip-up lens – This type of hood has a lens housing that can be flipped up so that it leaves a clear-glass lens, which permits the hood to be worn while cleaning. (FIG. 2-3) .

FIGURE 2-3



F. Selecting a safe lens shade for MIG

1. Determine electrode size and amperage range for the electrode.

2. In oxyacetylene welding and cutting, lens shade requirements are based on metal thickness, but in gas-shielded arc welding, lens shade requirements are based on electrode size, the amperage range of the electrode, and base metal properties.

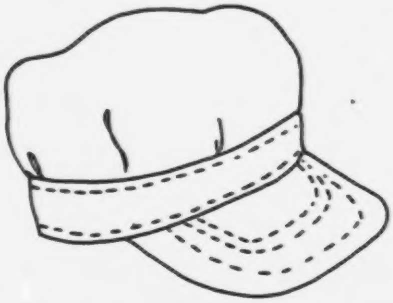
3. Select lens shade according to the lens manufacturer's selection chart.

4. When you remove your hood after welding and you see white spots or white blotches as after-images, it means that you are getting too much light through the lens.

G. Protective clothing for MIG welding

1. Welder's cap – Flexible bill can be used to cover either ear and keep sparks or metal spatter out of the ear opening. (FIG. 2-4)

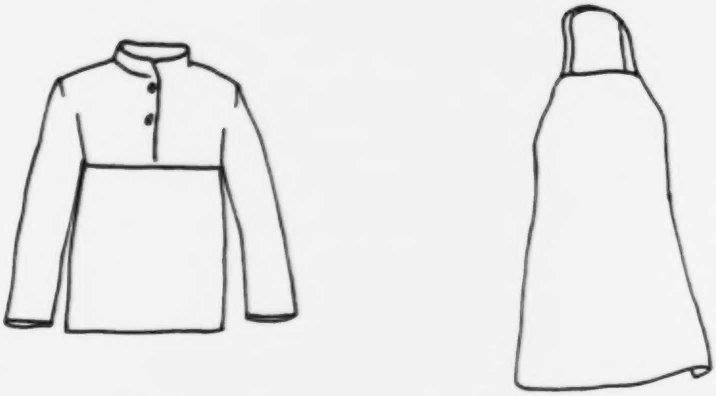
FIGURE 2-4



2. Shirts and pants – Heavy, long-sleeve shirts with pockets that have flaps, and cuffless pants. Avoid clothing made of synthetic materials.

3. Leather jackets and aprons – Should be worn for additional protection, especially when welding out of position or in confined areas where flying sparks present an increased hazard. (FIG. 2-5)

FIGURE 2-5

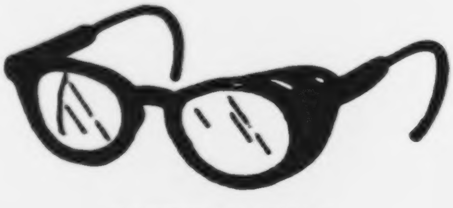


4. Boots – Should be made of heavy leather with uppers that reach above the ankle to help prevent burns from sparks and spatter. Although steel-toed boots are not required, they are highly recommended.

5. Gloves – Heavy leather gloves with gauntlets are required for all welding and cutting activities.

6. Safety glasses – Should have non-metal frames, impact-resistant lenses with side shields. Should be worn at all times in the shop area. (FIG. 2-6)

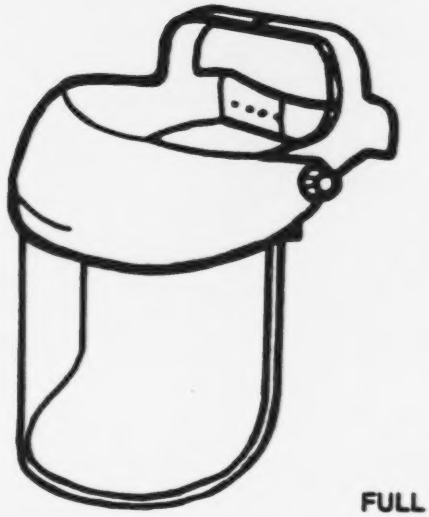
FIGURE 2-6



SAFETY GLASSES

7. Face shield – Provides good visibility when grinding or sanding base metals for MIG. (FIG. 2-7)

FIGURE 2-7



FULL FACE SHIELD

H. Environmental safety requirements

1. Ventilation – Many welding activities produce toxic fumes and vapors that are hazardous to breathe, and every work station should be equipped with a ventilation or exhaust system capable of safely removing dangerous and irritating smoke and contaminants.

   (**CAUTION:** *Always position your head to the side of rising fumes.)*

2. Respirators – In confined areas where the hazard of toxic fumes is greater, a welder should wear an air-supplied respirator.

   (**CAUTION:** *Argon is much heavier than air and will quickly displace oxygen.)*

3. Noise – This is a work place hazard frequently overlooked, but ear plugs or muffler-type ear protectors should be worn when the work area subjects a welder to high noise levels, especially high noise levels that are continuous.

4. Lighting – Lighting in a work area or at a work station should be bright enough to provide good visibility free of glare.

I. Safety guidelines for working with electrode wire

1. Always wear safety glasses when working with electrode wire because a loose end could spring up and severely injure an eye.

2. Make sure you have the correct spool or coil before loading and cutting tie wires.

3. Hold the free end of electrode wire firmly to avoid backlash during the reloading procedure. Failure to do so could ruin an entire spool or coil.
4. Never look into a gun while feeding wire through it, and never point the gun at anyone else.
5. Never place a finger or hand over a contact tip to see if the wire is feeding properly.

MODULE: WELDING

UNIT I: AUTO BODY WELDING AND MIG WELDING

UNIT I TEST

PART I—PRINCIPLES OF AUTO BODY WELDING

I. Match the terms in the right column with the correct definitions in the left column.

_____1. Gas metal arc welding

_____2. Metal inert gas

_____3. An inert gas such as argon or helium or a reactive gas such as CO2

_____4. An element or gas with no active properties

_____5. An element or gas with properties that will actively combine with other elements at a high temperature

_____6. Melting a brass rod to hold two pieces of metal together without fusing them

_____7. The use of electrodes on each side of two pieces of metal to be joined such that the pieces are fused surface-to-surface

A. Reactive

B. Consumable

C. Brazing

D. MIG

E. Deposition rate

AB. TIG

AC. Gas envelope

AD. GMAW

AE. Shielding gas

BC. Inert

BD. Resistance spot welding

II. Mark a T on the test or answer sheet if the statement is true and an F if the statement is false.

_____8. MIG welding is not suitable for vehicle repair.

_____9. Oxyacetylene welding generates too much heat for widespread usage in vehicle repair.

_____10. Oxyacetylene brazing is the preferred method of repairing modern vehicles.

_____11. Resistance spot welding is universally approved as a method of repair for structural panels on vehicles.

_____12. Beginners can be trained more quickly in the MIG process than any other type of welding.

_____13. Better welds are possible in MIG welding because the arc does not have to be visible to the operator.

_____14. MIG welding usually requires no clean-up and is easy to learn but it is more expensive than other welding processes.

_____15. MIG requires careful setting of electrical components.

_____16. As the arc is struck, a shielding gas is forced around the electrode wire in MIG welding.

III. Select the best answer from the choices listed.

_____17. MIG is necessary for auto body repair because of the wide use of: (a) CO_2, (b) mild steel, (c) high-strength steel, (d) MIG equipment, (e) TIG equipment.

_____18. The recommended shielding gas for auto body repair is: (a) Argon, (b) Helium, (c) CO_2, (d) 75% argon, 25% CO_2, (e) 75% Helium, 25% CO_2.

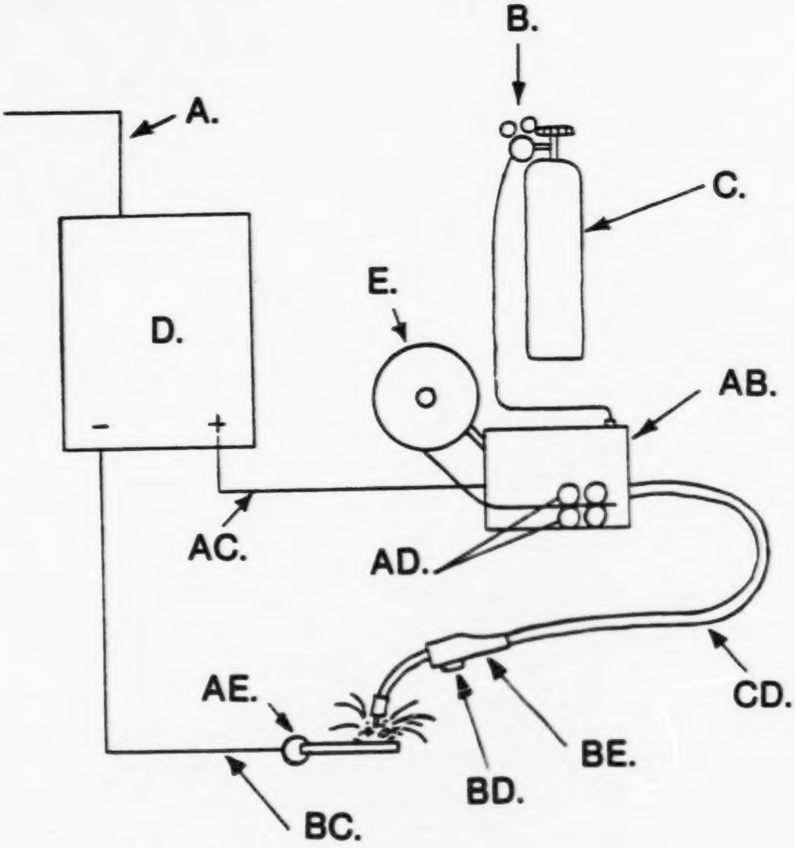
_____19. High-strength steel must be heated carefully because it: (a) melts at a low temperature, (b) becomes super-hard when heated, (c) loses strength if heated too much, (d) gives no warning that it's about to melt, (e) all of the above.

_____20. It is important not to damage high-strength steel by heating it too much in modern unibody vehicles because: (a) all body panels contribute to vehicle strength, (b) high-strength steel provides the frame of the vehicle, (c) it is expensive to replace, (d) it cannot be replaced, (e) both b and c.

_____21. High-strength steels come in many varieties and can only be distinguished by: (a) heating the metal, (b) looking for code marks on the metal, (c) using a vehicle service manual, (d) the metal's shiny appearance, (e) none of the above.

IV. Matching. Match the corresponding terms below with their proper location on the diagram of a MIG welder and mark the answer sheet accordingly.

_____22. Shielding gas cylinder
_____23. Welding power cable
_____24. Welding cable assembly
_____25. Work clamp
_____26. Welding gun
_____27. Main power supply cable
_____28. Wire spool
_____29. Wire feed and control unit
_____30. Regulator and flowmeter
_____31. Start/stop control level
_____32. Welding machine
_____33. Ground cable



(NOTE: Completion of this portion of the unit test is the evaluation for Competency F1 "Identify auto body welding processes." Of the 33 questions, a score of _____ correct = 3, _____ = 2, _____ = 1, _____ correct or below = student should retake this portion of the test.)

PART II–SAFETY

I. Mark a T on the test or answer sheet if the statement is true and an F if the statement is false.

_____34. Proper ventilation is important because the arc can reduce oxygen in the breathing zone around a welding activity.

_____35. In certain welding processes, poisonous gases, fumes and vapors can be produced by chemical reactions.

_____36. All electrical equipment should have an earth ground for safety reasons, and this ground should not be confused with the work lead-to-workpiece ground that completes the welding circuit.

_____37. Electrical connections should be kept tight, clean and dry because poor connections can heat up, cause bad welds, produce dangerous arcs and sparking, and even melt.

_____38. Keep work area, equipment and clothing dry because even a slight amount of moisture can conduct enough electricity to cause a severe shock.

_____39. Dip a gun in water to cool it only in emergencies.

_____40. Check the proper feeding of wire by placing your finger over the contact tip.

_____41. Keep welding cables as close to the work area as possible and do not connect cables to building framework because current can be directed through lifting chains and cables and weaken them.

_____42. A Class III welder is rated to deliver a duty cycle of 20%, meaning it can be operated 20 minutes out of each hour.

_____43. You should never strike an arc on a gas cylinder.

_____44. A welding arc produces ultraviolet and infrared radiation that can severely burn eyes that are unprotected with a proper shade of protective lens.

_____45. Radiation from a welding arc is strong enough to sunburn or blister bare skin.

_____46. Your eyes cannot be hurt by an arc flash if you are at least 10 feet away.

_____47. A welder's cap is used to keep sparks off the forehead.

_____48. You should wear heavy, long-sleeve shirts with flaps over the pockets and cuffless pants when welding.

_____49. You should wear a leather jacket or apron anytime you are welding in a confined area or when you are welding in an awkward position.

_____50. Boots for welding should be made of heavy leather with uppers that reach above the ankle, but steel-toed boots are too heavy and should not be worn.

_____51. Heavy leather gloves with gauntlets are required for all welding activities.

_____52. Safety glasses should always be worn when working with electrode wire because a loose end could spring up and severely injure an eye.

_____53. You should hold the free end of electrode wire firmly to avoid backlash during the reloading procedure, because failure to do so could ruin an entire spool or coil.

_____54. You should never look into a gun while feeding wire through it and never point the gun at anyone else.

(NOTE: Completion of this portion of the unit test is the evaluation for Compentency F2 "Use MIG welding safety procedures." Of the 21 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this portion of the test. A minimum score of ____ is also necessary for the student to receive an evaluation on Competency F13 "Use protective clothing and equipment.")

ANSWERS TO UNIT I TEST

PART I.

1. AD
2. D
3. AE
4. BC
5. A
6. C
7. BD

8. F
9. T
10. F
11. F
12. T
13. F
14. F
15. T
16. T

17. c
18. d
19. c
20. a
21. c

22. c
23. ac
24. cd
25. ae
26. be
27. a
28. e
29. ab
30. b
31. bd
32. d
33. bc

PART II.

34. T
35. T
36. T
37. T
38. T
39. F
40. F
41. T
42. F
43. T
44. T
45. T
46. F
47. F
48. T
49. T
50. F
51. T
52. T
53. T
54. T

MODULE: WELDING

UNIT II: MIG WELDING EQUIPMENT AND TECHNIQUES

UNIT OBJECTIVE

Upon completion of this unit the student should be able to identify and use MIG welding processes and equipment. Mastery will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Identify characteristics of short circuit transfer. (Competencies F3-F9, Unit II test)

II. Identify MIG controls and their functions (Competencies F3-F9, Unit II test)

III. Identify MIG welding wire (Competencies F3-F9, Unit II test)

IV. Identify MIG gun components and operation (Competencies F3-F9, Unit II test)

Lesson 2:

I. Identify MIG welding techniques (Competencies F3-F9, Unit II test)

II. Demonstrate the ability to:

- a. Set up a spool-type wire feeder for MIG (Competency F3, Job Sheet #1)
- b. Set up a flow meter regulator for shielding gases (Competency F3, Job Sheet #2)
- c. Set up equipment for short-circuit transfer (Competency F3, Job Sheet #3)
- d. Prepare metal for MIG welding (Competency F4, Job Sheet #4)

MODULE: WELDING

UNIT II: MIG WELDING EQUIPMENT AND TECHNIQUES

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. References

D. Lesson plans

1. Lesson 1: MIG Welding Process and Equipment

    a. Information outline

    b. Handouts

    HO#1: MIG welding variables

    c. Transparency masters

    TM#1: Types of gun tip components

2. Lesson 2: MIG Welding Techniques

    a. Information outline

    b. Handouts

    HO#1: Weld characteristics

    c. Job sheets

    JS#1: Set up a spool-type wire feeder for MIG
    JS#2: Set up a flow meter regulator for MIG shielding gases
    JS#3: Set up MIG equipment for short-circuit transfer on mild steel
    JS#4: Prepare steel for MIG welding

E. Unit test

F. Answers to unit test

REFERENCES USED IN WRITING THIS UNIT

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3. Fortney, Clarence, and Gregory, Mike. *Gas Metal Arc Welding and Flux-cored Arc Welding*. Mid-America Vocational Curriculum Consortium, Inc. Stillwater, OK. 1984.

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5. Hobart Brothers Company. *Technical Guide for Gas Metal Arc Welding*. Hobart Brothers Company. Troy, OH. 1980.

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12. Tweco Products, Inc. *MIG-GUN Installation & Operating Instructions*. Tweco Products, Inc. Wichita, KN. 1980.

13. Walters, Terry, and Walker, Susan. *Automotive Body Repairer*. Curriculum & Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education. Stillwater, OK. 1986.

MODULE: WELDING

UNIT II: MIG WELDING EQUIPMENT AND TECHNIQUES

LESSON ONE: MIG WELDING PROCESS AND EQUIPMENT

I. Characteristics of short-circuit metal transfer

A. Short-circuit transfer is a MIG application where low currents, low voltages, and small diameter wires are used to weld in all positions on thin to heavy metals. This is the type of MIG process in auto body repair.

B. Metal does not transfer across the arc, but melts off when the electrode wire makes contact with the base metal. (FIG. 1-1)

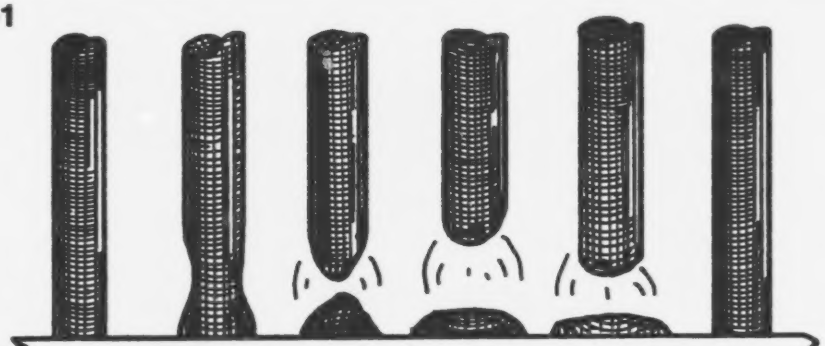
C. Amperage is controlled by wire-feed speed.

D. Operating voltages range from 15 to 22 volts, depending on wire size and shielding gas.

E. Relatively low-amperage, low-voltage, helps minimize heat dispersion.

F. Used with small-diameter wires

FIGURE 1-1



MECHANICS OF SHORT CIRCUITING TRANSFER

II. MIG machine controls and their functions

A. Basic MIG components

1. Power supply -- A rectifier-type DC welding machine with controls for current and voltage used in the basic MIG processes.

2. Wire feeder -- A roller device used to control the speed at which wire is fed to the welding arc.

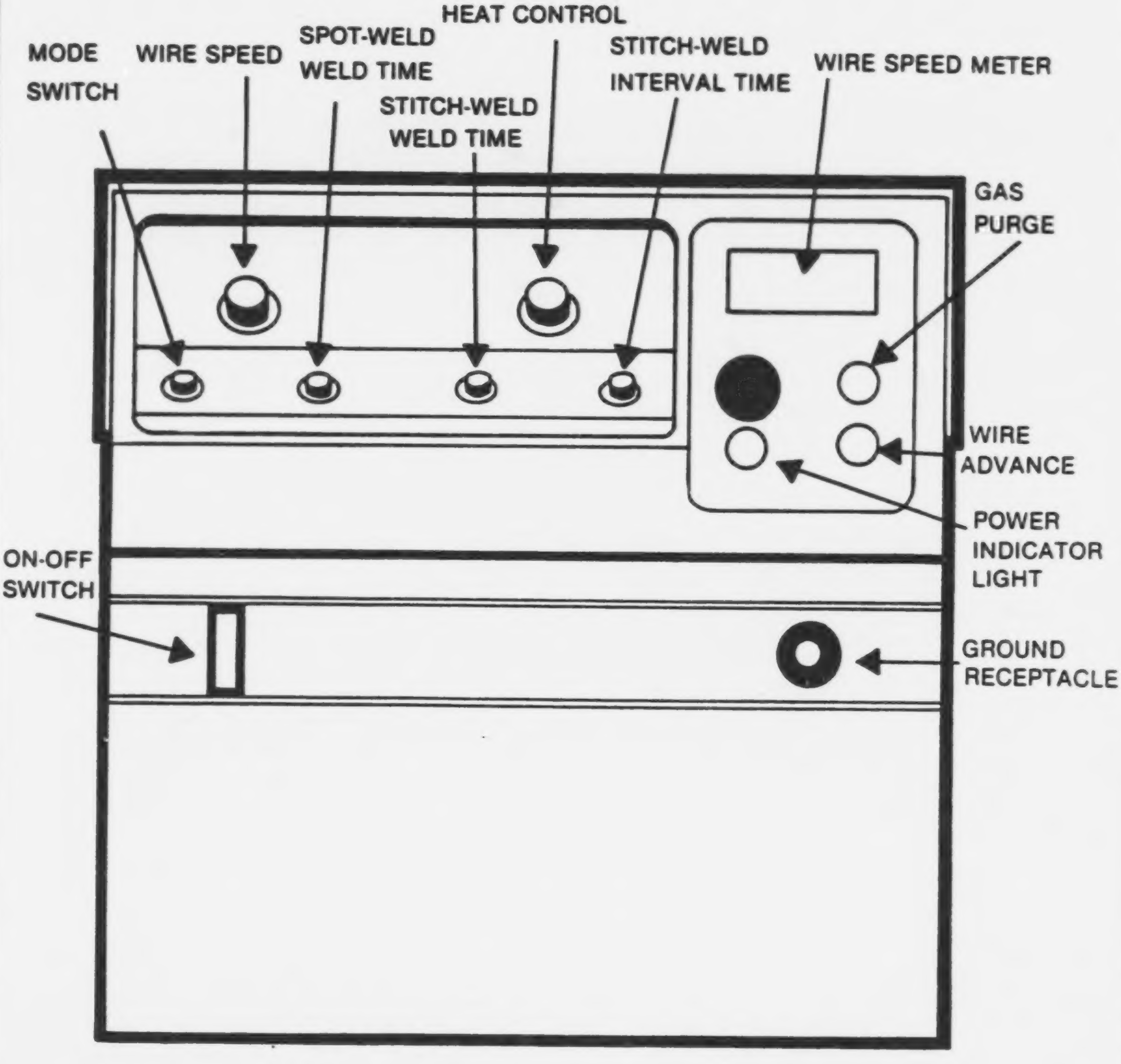
3. Gun-and-cable assembly – Cable transports power to trigger-operated gun through which the wire and shielding gas are fed.

4. Gun – Trigger-operated device through which wire and shielding gas are fed and directed.

5. Flowmeter regulator – Used to reduce high-pressure cylinder gas to low pressure gas so its flow rate can be controlled to the welding gun as measured in CFH (cubic feet per hour).

B. Typical MIG controls and their functions (FIG.1-2)

FIG. 1-2


HEAT CONTROL
MODE SWITCH
WIRE SPEED
SPOT-WELD WELD TIME
STITCH-WELD WELD TIME
STITCH-WELD INTERVAL TIME
WIRE SPEED METER
GAS PURGE
WIRE ADVANCE
POWER INDICATOR LIGHT
ON-OFF SWITCH
GROUND RECEPTACLE

Courtesy of Solar Division of Century Manufacturing Co.

1. Power switch -- Turns welder on or off.

2. Wire speed -- Adjusts the speed of wire flow.

3. Heat selector -- Selects heat range.

4. Mode switch -- Selects one of three welder operational modes: spot, continuous, or stitch.

5. Spot weld-weld time -- Adjusts length of time the arc is maintained when the mode switch is in the "spot" position.

6. Stitch weld-weld time -- Adjusts length of time the arc is maintained when the mode switch is in the "switch" position.

7. Stitch weld-interval time -- Adjusts length of time the arc is extinguished when the mode switch is in the "stitch" position.

8. Wire speed meter -- Measures the wire speed in inches per minute.

9. Gas Purge -- When this switch is pressed, only gas will flow. No wire feed, no welding current.

10. Wire Advance -- When this switch is pressed, only wire will feed. No gas flow, no welding current.

11. Power supply voltmeter and power supply ammeter -- Used on some units to calibrate and check voltage adjustments. (Not shown in FIG. 1-2.)

12. Contactor -- Used to complete circuit through wire feed and function as an on/off device for wire feed. (In tip of welding gun, not shown in FIG. 1-2.)

(NOTE: Some MIG welders designed for body shops have only a heat control and a wire feed control.)

C. Roll-adjustment requirements for wire feeders

1. When the tension on wire-feeder rollers is too tight, the rollers may flatten or shave the wire.

2. A flattened wire will usually "bird nest" at the feed roll and not feed through the cable.

3. A shaved wire creates small flakes of wire around the feed rolls and could create an electrical hazard or cause the wire to bird-nest.

4. Wire should be neither too tight nor too loose.

5. Most wire feeders have rollers for different sizes of wire and the proper roller size should be checked so it will properly roll the size wire being used.

D. Maintenance for wire feeders

1. Feed rolls should be checked regularly.

2. All electrical connections into and out of the feeder should be checked regularly and tightened as required.

3. The drag brake needs to be checked before each use to make sure it feeds off smoothly with no free-wheeling.

4. All gas hoses and connections should be inspected for leaks before each operation.

III. Electrode wires

A. AWS classifications for electrode wires

1. AWS classifications for electrode wires use letter and number designations to identify type of electrode and basic composition.

2. The letter "E" indicates electrode, and when followed by the letter "R," it indicates that the filler metal may be used as an electrode or welding rod.

3. Interior numbers indicate minimum tensile strength in multiples of 1,000 psi.

4. The letter "S" indicates a bare solid electrode or rod.

5. Final letter-number classifications indicate special chemical compositions of the electrode wire.

(Example: With an ER80S-B2 electrode wire the "E" indicates an electrode, the "R" indicates it can be used as a welding rod, the "80" indicates a strength of 80,000 pounds per square inch, the "S" indicates a solid wire and the "B2" indicates that the wire contains a certain amount of bismuth, an element with a low melting point to give the electrode that particular characteristic.)

6. The Inter-industry Conference of Auto Collision Repair (I-CAR) recommends using electrode wire that meets or exceeds E-70S-6, which is designed for use on high-strength steel.

B. Rules of thumb for MIG electrode wire selection

1. Solid electrode filler wires used for short-circuit transfer in auto body repair are usually very small diameter wires of .023" or .024".

2. The composition of the electrode wire should match the composition of the base metal on which it will be used.

C. Storing electrode wire

1. Spools and coils of electrode wire should not be opened or unsealed until they are needed.

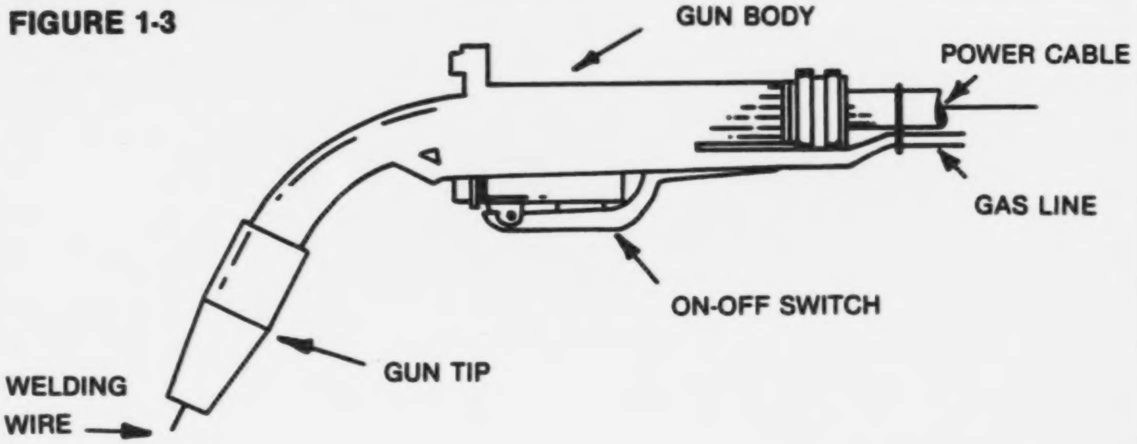
2. Electrode wires should be stored in a dry place.

3. Spools or coils should be used as soon as possible after opening, and remaining wire should be covered or resealed prior to storage.

IV. MIG gun components and operation

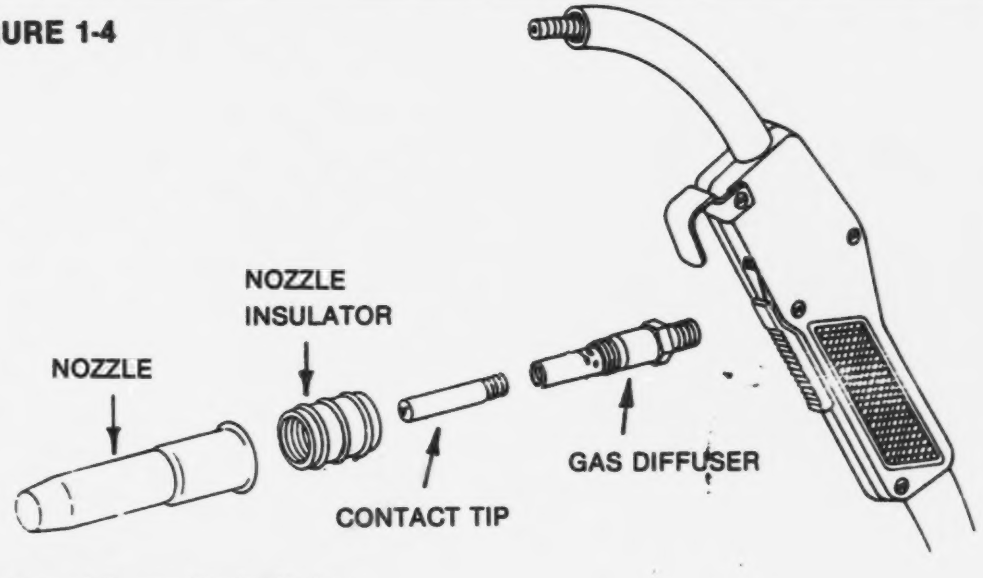
A. Basic MIG gun for auto body repair (FIG. 1-3)

FIGURE 1-3


GUN BODY
POWER CABLE
GAS LINE
ON-OFF SWITCH
GUN TIP
WELDING
WIRE

B. Parts of a gun tip and their functions (FIG. 1-4)

FIGURE 1-4


NOZZLE
INSULATOR
NOZZLE
GAS DIFFUSER
CONTACT TIP

Courtesy of Tweco Products, Inc.

1. Contact tip – A copper device used to guide the wire to the weld. It should be selected according to wire size and type of service.

2. Gas diffuser – A copper device that spreads shielding gas out so that it flows evenly over the electrode wire and the weld zone.

3. Nozzle insulator – A device which insulates the nozzle from the welding current and holds the nozzle in place.

4. Nozzle – Directs and holds shielding gas around the weld zone.

C. Steps in assembling contact tips, gas diffusers, nozzles, and insulators

   1. Screw gas diffuser into end of conductor tube assembly and tighten with an adjustable wrench, then tighten the Allen screw that holds the wire-feed conduit.

   2. Screw contact tip into the gas diffuser and secure it tightly with pliers.

   3. Slide the nozzle insulator over the diffuser and contact tip onto the conductor tube and hand-tighten.

   4. Slide the nozzle over the split-spring rings of the insulator and adjust.

D. Maintenance requirements for MIG guns.

   1. Contact tips need to be the right size for the wire being used and need to be kept tight.

   2. Gas diffusers need to be kept tight on conductor tubes.

   3. Nozzle and insulator should be cleaned periodically so the gas flow will be constant.

   4. Nozzle should be sprayed with anti-spatter gel so it will remain as spatter-free as possible.

   5. Cables should be free of kinks at all times.

E. ESO and its function

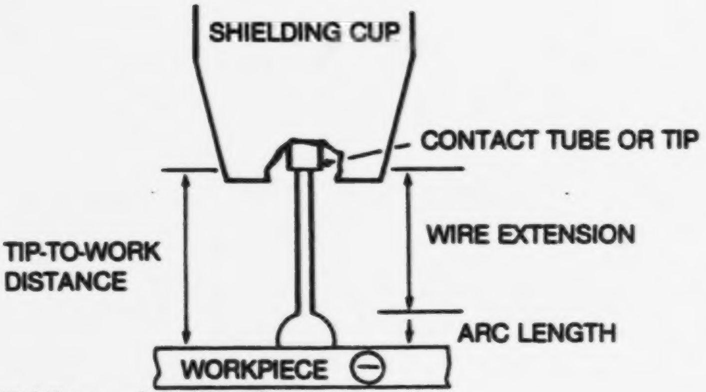
   1. ESO (electrode stickout) gives an operator control of slight but critical adjustments of amperage and voltage needed to correct spatter, penetration, and bead width.

   2. Too much ESO decreases amperage and slightly increases voltage. This results in more arc and produces spatter and poor penetration.

3. Too little ESO increases amperage and slightly decreases voltage and results in less arc. This produces no spatter and good penetration, but results in a narrow bead with overall poor fusion.

4. A normal ESO for short-circuit transfer is 1/4" to 3/8". (FIG. 1-5)

FIGURE 1-5



Courtesy of L-TEC Welding and Cutting Systems

F. Basic MIG shielding gases and their uses

1. Argon, CO_2 and oxygen are the three basic MIG shielding gases and are frequently used in combinations to accomplish specific MIG applications.

2. Argon is the most frequently used shielding gas because it produces a clean, narrow bead with deep penetration on nonferrous metals.

3. CO_2 is used primarily because it is far less expensive than other shielding gases, but it can cause an unstable arc and produce spatter if not used carefully. It also requires electrode wires with deoxidizing agents.

4. Oxygen is used in varying percentage combinations with argon on both mild and stainless steel.

HO 1

GMAW WELDING VARIABLES

WELDING VARIABLES TO CHANGE	DESIRED CHANGES							
	PENETRATION		DEPOSITION RATE		BEAD SIZE		BEAD WIDTH	
	↑	↓	↑	↓	↑	↓	↑	↓
CURRENT & WIRE FEED SPEED	↑	↓	↑	↓	↑	↓	*	*
VOLTAGE	+	+	*	*	*	*	↑	↓
TRAVEL SPEED	+	+	*	*	↓	↑	↑	↓
STICKOUT	↓	↑	↑	↓	↑	↓	↓	↑
WIRE DIAM.	↓	↑	↓	↑	*	*	*	*
SHIELD GAS % CO_2	↑	↓	*	*	*	*	↑	↓
TORCH ANGLE	BACK HAND TO 25°	FORE HAND	*	*	*	*	BACK HAND	FORE HAND

** NO EFFECT*
+ LITTLE EFFECT
↑ INCREASE
↓ DECREASE

Courtesy of L-TEC Welding and Cutting Systems

MODULE: WELDING

UNIT II: MIG WELDING EQUIPMENT AND TECHNIQUES

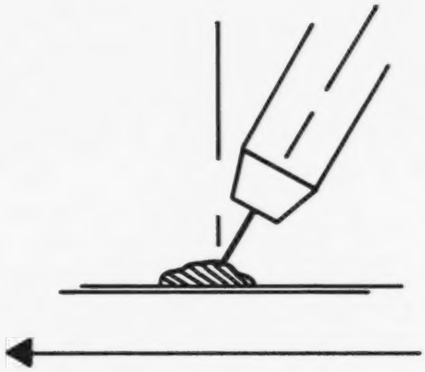
LESSON TWO: MIG WELDING TECHNIQUES

I. **Basic MIG techniques**

A. Push technique (forehand technique)

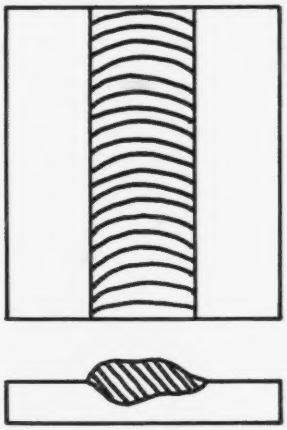
1. Electrode points in the direction of welding. (FIG. 2-1)

FIGURE 2-1



2. Push technique decreases penetration and gives a wider, flatter bead. (FIG. 2-2)

FIGURE 2-2

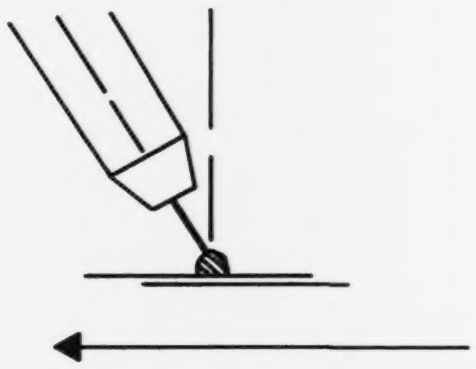


3. Push technique is mostly used on thicker materials.

B. Pull technique (backhand or drag technique)

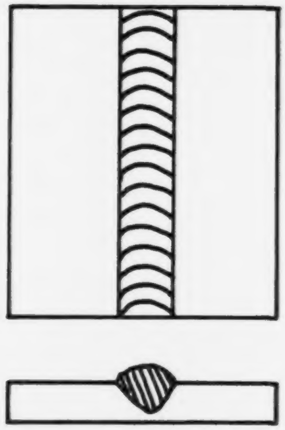
1. Electrode points opposite the direction of welding. (FIG. 2-3)

FIGURE 2-3



2. Pull technique increases penetration, gives a more convex, narrow bead, provides a more stable arc, and leaves less spatter on the workpiece (FIG. 2-4).

FIGURE 2-4



3. Pull technique is used mostly on thinner materials.

4. Pull technique will be used in most auto body repair.

C. Techniques for ending a weld properly

1. To end a weld properly, the crater should be filled.

2. The most common technique for ending a weld is as follows.

   a. Release the gun trigger just as the bead reaches the end of the weld.

b. Hold the gun in place and hesitate for just a second to keep the molten puddle covered with shielding gas.

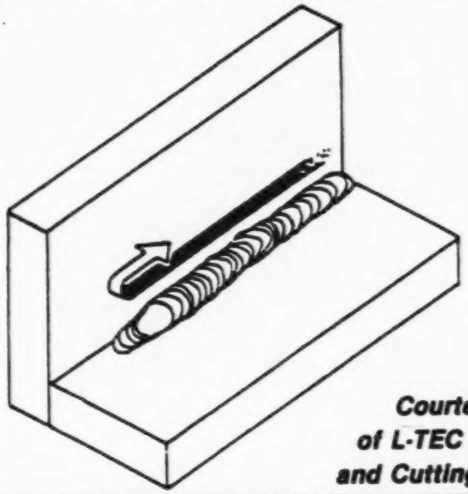
c. Pull the gun away.

(NOTE: The slight hesitation after releasing the trigger is the key to making this method work because the burn-back control will continue action just long enough for the crater to fill and end the weld properly.)

3. An alternate technique for ending a weld is to:

a. Reverse the travel direction before breaking the arc. (FIG. 2-5)

FIG. 2-5



Courtesy of L-TEC Welding and Cutting Systems

b. After breaking the arc, keep the gun in place briefly so the crater will be shielded until it completely solidifies.

(NOTE: Using this technique is essential for welding out of corners where the weld has to start at a corner and be completed at a more accessible point.)

D. Characteristics of a good weld

1. Even ripple on bead

2. Slight crown (convex) at root

3. Well-fused throughout joint

E. Common welding mistakes

1. Cold lapping (incomplete fusion)

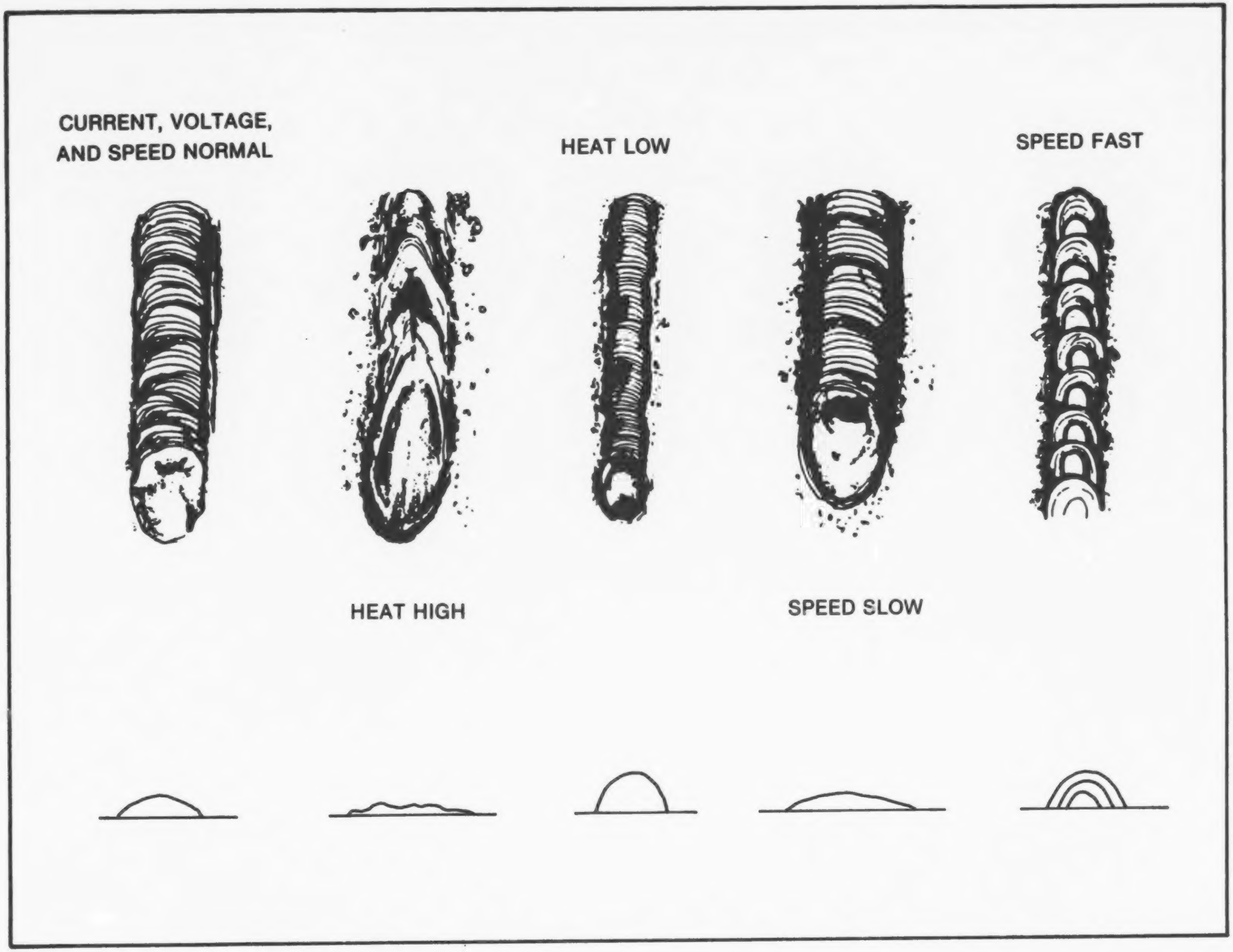
2. Excessive penetration

3. Insufficient penetration
4. Burn-through
5. Surface porosity
6. Poor appearance
7. Whiskers
8. Bad tie-in
9. Suck-back (internal concavity)
10. Improper ESO
11. Improper angle
12. Improper gas flow
13. Improper use of anti-spatter
14. Dirty nozzle
15. Failure to remove glass slag

F. Important points to remember in MIG

1. Keep contact tip and nozzle clean and tight at all times. Use anti-spatter gel as welding conditions require.
2. Keep all cables free of kinks.
3. Change only one variable at a time when adjusting.
4. Keep arc in leading edge of puddle.
5. Do not move tip too quickly – will cause spatter.

GOOD AND BAD WELDS


CURRENT, VOLTAGE, AND SPEED NORMAL
HEAT HIGH
HEAT LOW
SPEED SLOW
SPEED FAST

UNIT II

JOB SHEET #1, LESSON TWO

SET UP A SPOOL-TYPE WIRE FEEDER FOR MIG

Equipment:

MIG machine and accessories
Personal safety clothing and equipment
MIG wire, spool or coil
Screwdriver
Adjustable wrench
Wire-cutting pliers
Fine-cut file
Nozzle spray or gel

Procedure: **Evaluation:** 3 2 1 N

1. Shut off input power to power supply and wire feeder and put on safety glasses and personal safety clothing. ___ ___ ___ ___
2. Remove nozzle from MIG gun. ___ ___ ___ ___
3. Cut tip of wire off at ESO if replacing wire. ___ ___ ___ ___
4. Use pliers to slide contact tip out over wire and be careful not to remove the gas diffuser. ___ ___ ___ ___
5. Release spring tension off the feed roll. ___ ___ ___ ___
6. Pull remaining wire through cable and gun, if replacing wire, and dispose of it. ___ ___ ___ ___
7. Remove the retaining collar that holds the spool in place by loosening the thumb screw or removing the cotter pin that secures it. ___ ___ ___ ___
8. Remove the empty spool from the spindle. ___ ___ ___ ___
9. Locate the end of the wire on the new spool and position the new spool so that wire will feed from the bottom of the spool into the wire feeder. ___ ___ ___ ___

   (**CAUTION:** *Do not remove the free end of the wire from the retaining hole where it is secured or you'll have wire all over the place.*)

Procedure:

Evaluation:
3 2 1 N

10. Place the new spool or wire onto the spindle and make sure the drag brake pin slips into the proper hole. ___ ___ ___ ___

11. Place the retaining collar back on the spindle, force it tightly against the reel, and tighten the thumb screw or replace the cotter pin that secures it. ___ ___ ___ ___

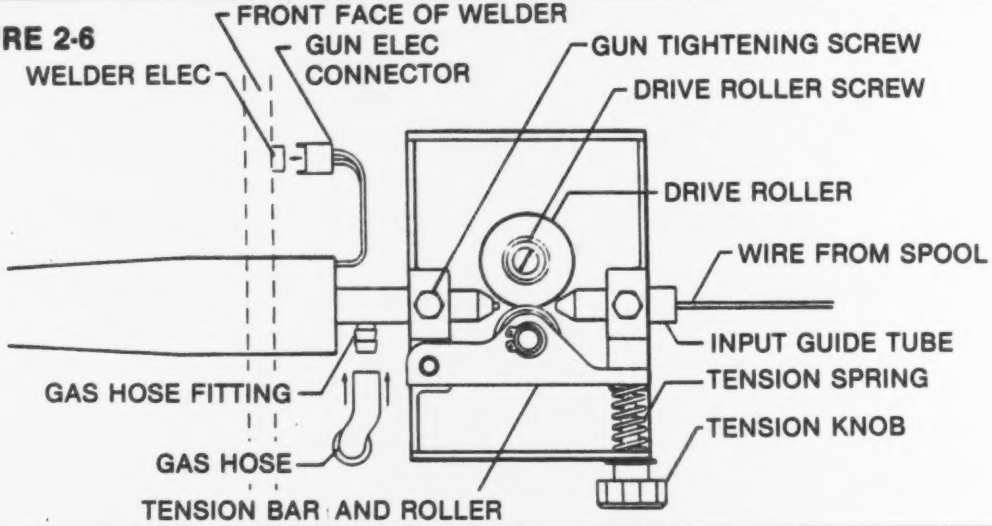
12. Locate the end of the wire on the spool, free it from the retaining hole, and clip the end of the wire. ___ ___ ___ ___

    (CAUTION: *Hang on to the free end of the wire firmly throughout this procedure.)*

13. Use a file to smooth the sharp end of the wire. ___ ___ ___ ___

14. Guide the clean, free end of the wire through the insulated input guide and use both hands to push and pull the wire across the top of the bottom feed roller and through the insulated output guide (Fig. 2-6). ___ ___ ___ ___

FIGURE 2-6


FRONT FACE OF WELDER
GUN ELEC CONNECTOR
WELDER ELEC
GUN TIGHTENING SCREW
DRIVE ROLLER SCREW
DRIVE ROLLER
WIRE FROM SPOOL
INPUT GUIDE TUBE
TENSION SPRING
TENSION KNOB
GAS HOSE FITTING
GAS HOSE
TENSION BAR AND ROLLER

Courtesy of Solar Division of Century Manufacturing Co.

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
15. Continue pushing and pulling the wire until it moves into and through the wire-feed power assembly 2" to 3."				
***(CAUTION:** Do not force the wire into the wire-feed assembly, work it back and forth until it fits smoothly.)*				
16. Bring top feed roll down so that the wire lies in the groove between both the rollers.				
17. Use a screwdriver, or thumb screw, to tighten the pressure-adjusting screw to provide operating pressure between the bottom and top rollers.				
***(CAUTION:** Do not overtighten the adjusting screw, causing the wire to flatten out.)*				
18. Turn on power supply and wire-feed power.				
19. Position gun so that the cable conduit between the wire feeder and gun is straight.				
(NOTE: Use the wire-inch for the following adjustment because it will help keep from shorting out the gas diffuser and wasting expensive shielding gas. If machine does not have a wire-inch, be especially attentive to the procedure.)				
20. Turn on the wire-inch and feed the wire through the cable conduit to the gun while testing tension on the feed roller with the following procedure:				
a. Pinch the wire just ahead of the insulated input guide.				
b. If a slight pinching pressure will stop the wire from feeding through, the tension is probably all right.				
c. If a slight pinching pressure will not stop the wire from feeding through, the tension is probably too much.				
21. Turn off power supply and wire-feed supply, then replace the contact tip required for the size wire you are using, then tighten the contact tip with pliers.				

Procedure:	**Evaluation:** 3	2	1	N
22. Replace nozzle over contact tip and have instructor check your work.	___	___	___	___
(NOTE: The procedure for replacing a coil-type wire reel is essentially the same as a spool-type reel, except that the coil-type reel has a spring-loaded device to secure and release it so that the reel separates into two halves in order for replacement coil to be installed.)				
23. Adjust machine for specified welding activity or turn off machine and store properly.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average will become part of Job Sheet #3, this lesson, for part of the Job Sheet #3 evaluation.)

UNIT II

JOB SHEET #2, LESSON TWO

SET UP A FLOW METER REGULATOR FOR MIG SHIELDING GASES

(NOTE: Many machines have a gauge, adjust according to welding machine manufacturer's instructions.)

Equipment:

Propane gas cylinder
Flow meter regulator
Adjustable wrench or open-end wrench
Safety glasses

Procedure:	**Evaluation:** 3	2	1	N
1. Check to see that gas cylinder is safely secured in an upright position and remove cylinder cap.				
2. Crack cylinder valve slightly to clear cylinder valve fitting, then check gasket and attach flow meter regulator to the cylinder valve.				
3. Tighten regulator fitting nut with wrench, but do not overtighten, then check to make sure that flow meter adjusting valve is shut off, and if it isn't, turn it clockwise until it is tight.				
4. Open gas cylinder valve all the way so that it will back seat against the top of the valve.				
5. Set up and turn on MIG machine. *(NOTE: Check with instructor.)*				
6. Turn flow meter adjusting screw counter-clockwise until the ball starts to rise in the flow meter. *(NOTE: If ball is not rising, check to see if wire feed is turned on.)*				

Procedure:

Evaluation:
3 2 1 N

7. Move the adjusting screw clockwise or counter-clockwise to make adjustment to CFH desired. ___ ___ ___ ___

   (NOTE: The very top of the ball is the reference point for measuring CFH.)

8. Have your instructor check your work, then shut down and secure equipment or prepare for next job sheet as directed by instructor. ___ ___ ___ ___

   Average of above evaluations* ___ ___ ___ ___

   (*This average will become a part of the evaluation on Job Sheet #3.)

UNIT II

JOB SHEET #3, LESSON TWO

SET UP MIG EQUIPMENT FOR SHORT-CIRCUIT TRANSFER ON STEEL

Equipment:

MIG machine with accessories
Personal safety clothing and equipment
Wire to specifications
Shielding gas to specifications
Mild, stainless or HSS steel as selected by instructor
Adjustable wrench

Procedure:	**Evaluation:**			
	3	2	1	N
1. Set up spool-type wire feeder by performing Job Sheet #1.				
2. Attach the flow meter regulator to the shielding gas by performing Job Sheet #2. (If needed.)				
3. Attach ground clamp to workpiece and turn on machine.				
4. Adjust voltage and amperage (heat) to approximate settings for wire size and metal thickness.				
5. Place a piece of scrap metal on the work table so that it is behind you and you are facing the meters on the machine, then turn wire feed power on and adjust amp/ipm control.				
6. Place the nozzle of the gun on the piece of scrap metal so that the correct ESO can be maintained. Face the machine meters, keep the gun behind you, and pull the trigger to create an arc.				
7. Observe voltage and amp/ipm meters quickly and make a mental note of their settings.				
8. Release the trigger to break the arc and make adjustments as needed to correct voltage and amp/ipm.				
9. Run a test bead on the piece of scrap metal and listen carefully for a sound like of bacon frying on a slightly-too-hot fire.				

Procedure: **Evaluation:**

3 2 1 N

10. Release the trigger and inspect the bead and make corrections as follows: ___ ___ ___ ___

    a. If the bead is flat and wide, lower voltage or increase wire amp/ipm.

    b. If the bead is narrow and humpy, raise voltage and decrease wire amp/ipm.

    c. If there is excess spatter, adjust according to machine manufacturer's recommendations.

    d. If there is poor shape or undercutting, correct gun angle, ESO, or travel speed.

    e. Repeat procedure until settings are proper and bead has good appearance.

11. Inspect your bead for good penetration, good fusion, and uniform width with minimum spatter, then have your instructor check your work. ___ ___ ___ ___

12. Shut off wire-speed feed control, set control to zero, depress gun trigger to to relieve shielding gas pressure. Allow ball in flow meter to return to zero. ___ ___ ___ ___

13. Turn off feed-control power switch, turn off welding machine power supply, set voltage at zero and store equipment in a safe place. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for Competency F3 "Set up equipment for MIG welding.")

UNIT II

JOB SHEET #4, LESSON TWO

PREPARE STEEL FOR MIG WELDING

Equipment:

Personal safety clothing
Safety glasses
Wire brush
Portable grinder and sanding equipment
Material as selected by instructor
Pliers and clamps
Clean shop rags

Procedure:

Evaluation:
3 2 1 N

1. Secure workpiece with pliers or clamps. ___ ___ ___ ___

2. Remove mill scale, rust, dirt, and paint from all surfaces with portable sander. ___ ___ ___ ___

   (If working on zinc-coated metal, be careful not to remove the zinc.)

3. Grind edges of joints for specified edge preparation. ___ ___ ___ ___

4. Wire-brush as required. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for competency F4 "Prepare metal for MIG welding.")

MODULE: WELDING

UNIT II: MIG WELDING EQUIPMENT AND TECHNIQUES

UNIT II TEST

I. Mark a T on the test or answer sheet if the statement is true and an F if the statement is false.

_____1. In MIG welding, metal does not transfer across the arc but melts off when the electrode wire makes contact with the base metal.

_____2. Amperage is controlled by voltage.

_____3. The power supply is a rectifier-type DC welding machine.

_____4. The power for the arc, as well as the shielding gas and the wire, all pass through the gun-and-cable assembly.

_____5. The wire feeder controls the shielding gas flow rate.

_____6. The flowmeter regulator reduces high-pressure gas to low-pressure gas so its flow rate can be controlled at the gun.

_____7. Shielding gas is only needed for welding on high-strength steel.

_____8. Argon, CO_2 and Nitrogen are the three basic shielding gases.

II. Match MIG controls with their functions by matching the term in the right column with the function in the left column.

_____9. Used to start or stop the electrical power to a MIG machine

_____10. Used to make the heat selection

_____11. Used to calibrate and check voltage, and amperage

_____12. Used to complete circuit through wire feed and function as an on/off device for wire feed

A. Heat selector

B. Contactor

C. Voltflow meter

D. Power switch

E. Power supply voltmeter/ammeter

III. Match MIG controls with their functions by matching the term in the right column with the function in the left column.

_____13. Used to control wire feed speed.

_____14. Functions as a control to select one of the three welder operations: spot, continuous or stitch.

_____15. An on/off device that routes current through a timer, which provides a specific time for each trigger activation regardless of how long the trigger is held.

_____16. A device to permit the flow of a shielding gas through the gun without having wire feed at the same time.

_____17. Used to advance wire for setting up purposes and does not activate other components.

_____18. An on/off device that routes current through a timer which provides a specific time for a weld and a specific interval between welds.

A. Reverse control

B. Wire speed

C. Mode switch

D. Wire advance

E. Stitch weld function

AB. Gas purge

AC. Spot weld function

AD. Contactor

IV. Select the best answer from the choices listed.

_____19. When the tension on wire feeder rolls is too tight, the rolls may: (a) flatten, (b) shave the wire, (c) break, (d) feed too slowly, (e) either a or b.

_____20. A flattened wire will usually: (a) break, (b) feed too slowly, (c) birds nest, (d) feed too quickly, (e) either a or b.

_____21. In order to change wire sizes, you have to be sure that the wire feeders have: (a) the proper size rollers, (b) enough clearance, (c) special feeder controls, (d) the right speed, (e) both b and c.

_____22. In the AWS classification ER-80S-D2 what does the "E" stand for?: (a) electrode, (b) welding rod, (c) a bare, solid electrode or rod, (d) everyday usage, (e) special usage.

_____23. In the AWS classification ER-80S-D2 what does the "R" stand for: (a) electrode, (b) welding rod, (c) a bare, solid electrode or rod, (d) everyday usage, (e) special usage.

_____24. In the AWS classification ER-80S-D2 what does the "S" stand for: (a) electrode, (b) welding rod, (c) a bare, solid electrode or rod, (d) everyday usage, (e) special usage.

_____25. The composition of the electrode wire should: (a) match the base metal, b) complement the base metal, (c) have some exotic elements, (d) match the shielding gas, (e) dampen current flow.

____26. Electrode wires must be sealed and stored: (a) on a wooden shelf, (b) on concrete, (c) on non-conductive metal, (d) in a dry place, (e) either a or b.

____27. The nozzle insulator insulates the nozzle from the welding current and: (a) guides the wire to the weld, (b) spreads the shielding gas out, (c) holds the nozzle in place, (d) directs and holds the shielding gas in the weld zone, (e) controls wire speed.

____28. The contact tip: (a) guides the wire to the weld, (b) spreads the shielding gas out, (c) holds the nozzle in place, (d) directs and holds the shielding gas in the weld zone, (e) controls wire speed.

____29. The nozzle: (a) guides the wire to the weld, (b) spreads the shielding gas out, (c) holds the nozzle in place, (d) directs and holds the shielding gas in the weld zone, (e) controls wire speed.

____30. The gas diffuser: (a) guides the wire to the weld, (b) spreads the shielding gas out, (c) holds the nozzle in place, (d) directs and holds the shielding gas in the weld zone, (e) controls wire speed.

____31. Which of the following is NOT a maintenance requirement for MIG welding guns: (a) contact tips need to be right size for wire being used and need to be kept tight, (b) gas diffusers need to be kept tight on conductor tubes, (c) gun should be oiled frequently, (d) nozzle and insulator should be cleaned periodically, (e) nozzle should be sprayed with anti-spatter gel.

____32. The three main characteristics of a good weld are: (a) flat surface, whiskers, even ripple, (b) flat surface, good fusion, even ripple, (c) slight crown, good fusion, even ripple, (d) slight crown, whiskers, surface porosity, (e) slight crown, surface porosity, good fusion.

V. Arrange in order the steps of assembling contact tips, gas diffusers, nozzles and insulators by placing the following in the correct order on answer sheet spaces 38, 39, 40 and 41. The letter of the first step in answer 38, the next step in 39, and so on.

____33. Slide the nozzle over the split-spring rings of the insulator and adjust.

____34. Screw contact tip into the gas diffuser and secure it tightly with pliers.

____35. Slide the nozzle insulator over the diffuser and contact tip onto the conductor tube and hand-tighten.

____36. Screw gas diffuser into end of conductor-tube assembly and tighten with an adjustable wrench, then tighten the Allen screw that holds the wire-feed conduit.

VI. Mark a T on the test or answer sheet if the statement is true and an F if the statement is false.

____37. Too much ESO decreases amperage and slightly decreases voltage and results in more arc, which produces spatter and poor penetration.

____38. Too little ESO increases amperage and slightly increases voltage and results in less arc, which gives no spatter and good penetration, but produces a narrow bead with overall poor fusion.

_____39. A normal ESO for short-arc transfer is one to two inches.

_____40. The push technique decreases penetration and gives a wider, flatter bead.

_____41. The pull technique increases penetration and gives a narrower bead and leaves less spatter.

_____42. The most common way of ending a weld properly is to release the gun trigger as the bead ends the weld and hold the gun in place for a second to keep it covered with shielding gas before pulling the gun away.

(NOTE: Completion of this unit test with a minimum score of ____ is necessary for the student to receive evaluations on Competencies F3-F9.)

ANSWERS TO UNIT II TEST

1. T
2. F
3. T
4. T
5. F
6. T
7. F
8. F

9. D
10. A
11. E
12. B

13. B
14. C
15. AC
16. AB
17. D
18. E

19. E
20. C
21. A
22. A
23. B
24. C
25. A
26. D
27. C
28. A
29. D
30. B
31. C
32. C

33. D
34. B
35. C
36. A

37. F
38. F
39. F
40. T
41. T
42. T

MODULE: WELDING

UNIT III: APPROVED AUTO BODY MIG WELDS

UNIT OBJECTIVE

Upon completion of this unit the student should be able to identify and use approved auto body MIG welds and techniques. Mastery will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Identify MIG techniques and specific welds (Competencies F5-F9, Unit III test)

II. Demonstrate the ability to:

   a. Construct a MIG plug weld (Competencies F5, F6, F9, Job Sheet #1)

   b. Construct a MIG continuous weld (Competencies F5, F7, F9, Job Sheet #2)

   c. Construct a MIG stitch weld (Competencies F5, F8-F9, Job Sheet #3)

MODULE: WELDING

UNIT III: APPROVED AUTO BODY MIG WELDS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

  1. Lesson 1: Approved Auto Body Welds and Techniques

    a. Information outline

    b. Job sheets

      JS#1: Construct a MIG plug weld
      JS#2: Construct a MIG continuous weld
      JS#3: Construct a MIG stitch weld
      JS#4: Pass a MIG weld destructive test

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Students should practice making plug welds, stitch welds and continuous welds on scrap metal until they are proficient. They can be evaluated on scrap sheet metal, but it would be preferable to evaluate them on welding HSS components. If they perform the weld on HSS unibody structural components, it also serves as the evaluation for competency F9 "Weld high strength steel unibody structural components."

REFERENCES USED IN WRITING THIS UNIT

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MODULE: WELDING

UNIT III: APPROVED AUTO BODY MIG WELDS

LESSON ONE: APPROVED AUTO BODY MIG WELDS AND TECHNIQUES

I. **MIG techniques and specific welds**

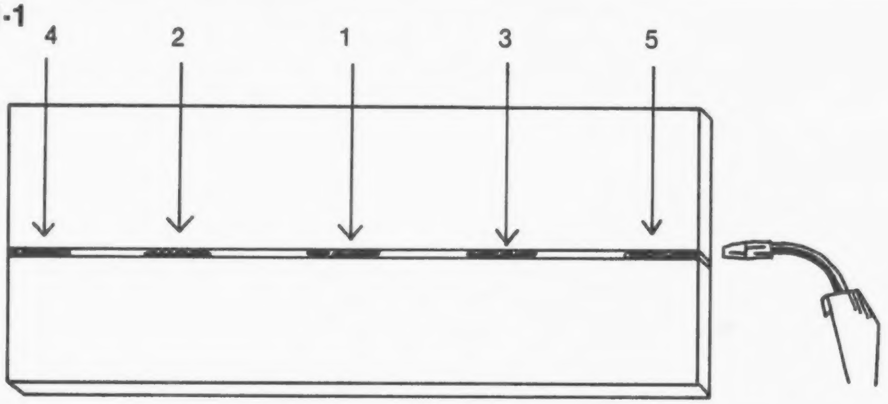
A. Continuous welds

1. Continuous welds are seldom made in one beginning-to-end pass in vehicle panel repair.

2. Continuous welds are formed by leaving gaps and filling them in or by using the stitch weld capability of some MIG welders.

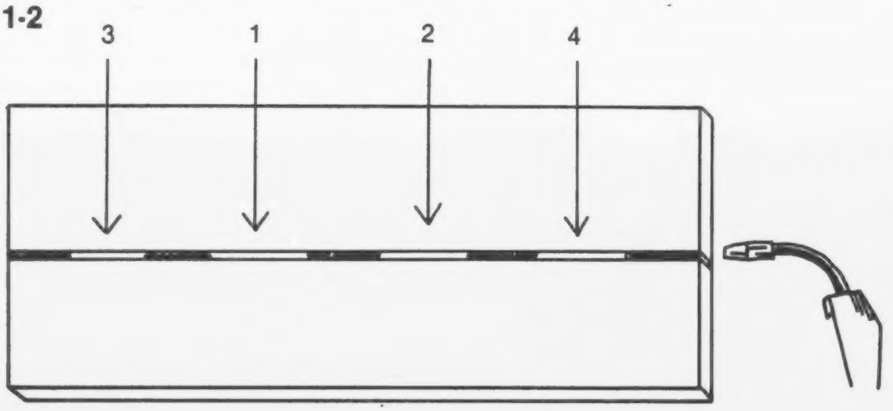
a. To continuous weld using gap method, weld using no more than a two-inch seam according to the following pattern. (FIG. 1-1)

FIGURE 1-1



b. To fill in gaps and complete continuous weld, weld gaps in the following pattern. (FIG. 1-2)

FIGURE 1-2



c. Be sure gaps are closed completely.

d. Purpose is to control heat distortion of metal.

B. Stitch welds

1. Accomplishes same thing as alternating gap method by shutting machine off at preset intervals to allow metal to cool between welds

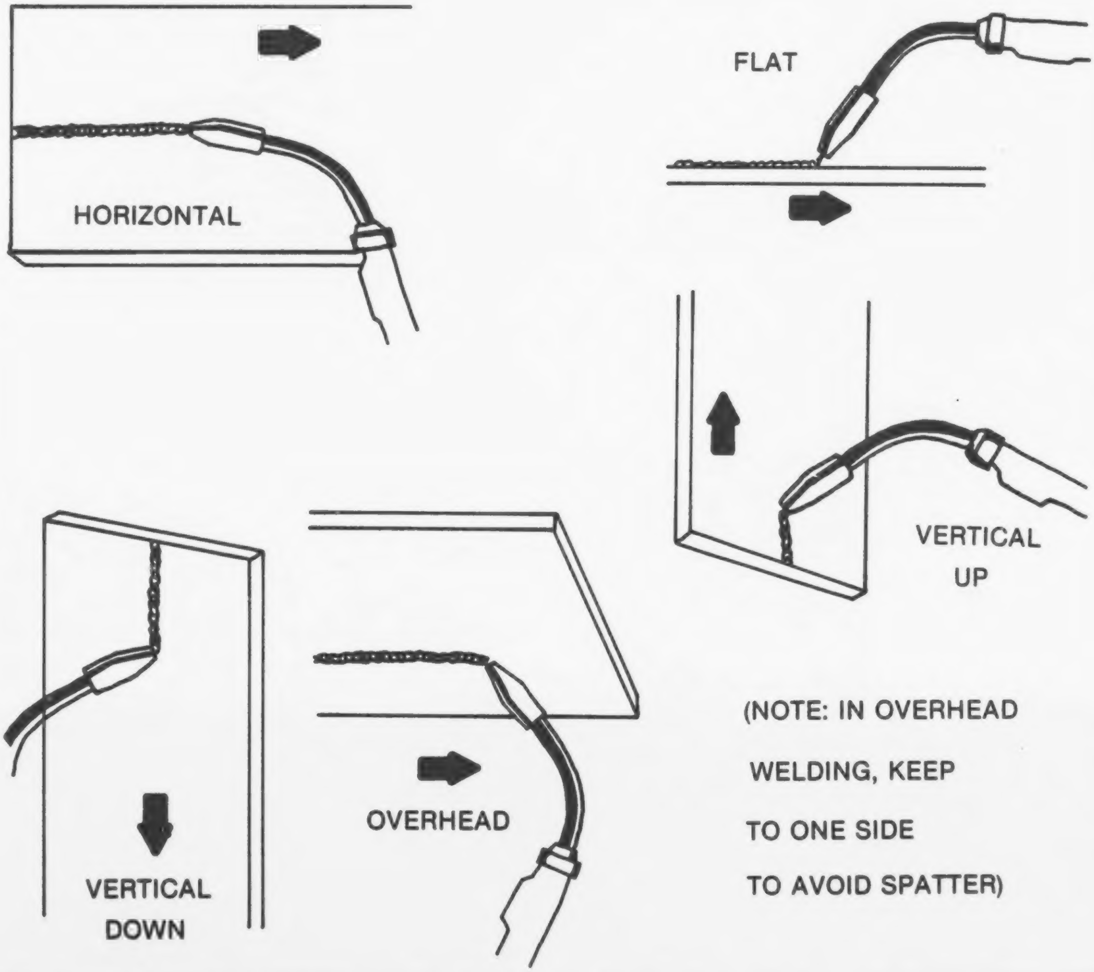
2. Weld is made continuous - gaps not needed due to cooling when machine shuts off.

3. Interval of shutting off machine is short - less than one second in most cases.

C. Positions and techniques

1. The five types of weld positions (FIG. 1-3)

FIGURE 1-3

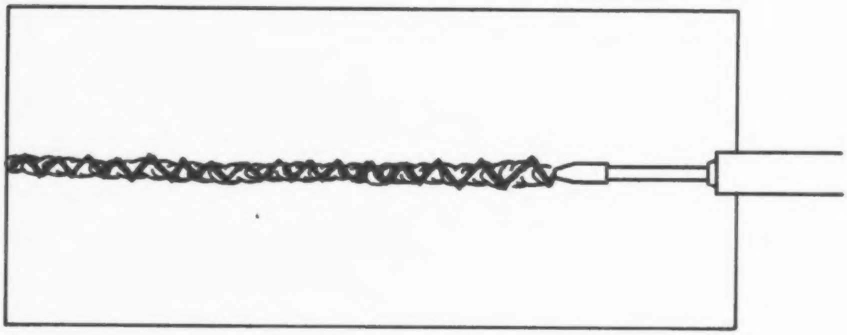


(NOTE: IN OVERHEAD WELDING, KEEP TO ONE SIDE TO AVOID SPATTER)

Courtesy of Solar Division of Century Manufacturing Co.

2. In most approved auto body welds, a slight weaving motion of the welder is required. (FIG. 1-4)

FIGURE 1-4

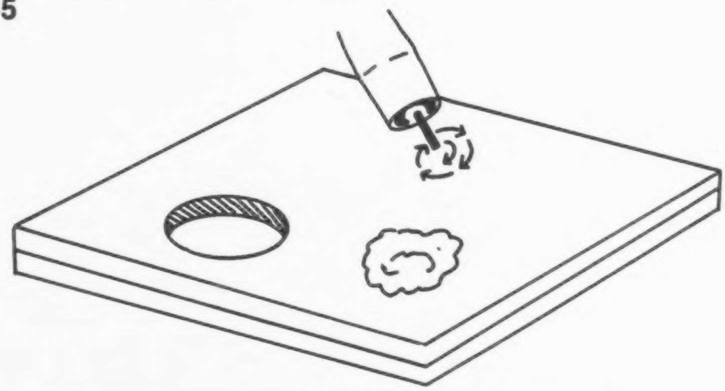


D. Welds approved by the Inter-Industry Conference on Auto Collision Repair (I-CAR) for collision repair on both structural and non-structural panels for unibody vehicles

(NOTE: With unibody vehicles now dominating the industry, the following welds will be those most often employed in modern vehicle repair.)

1. Plug weld (FIG. 1-5)

FIGURE 1-5



a. Used as replacement for factory spot welds

b. Can be done from one side

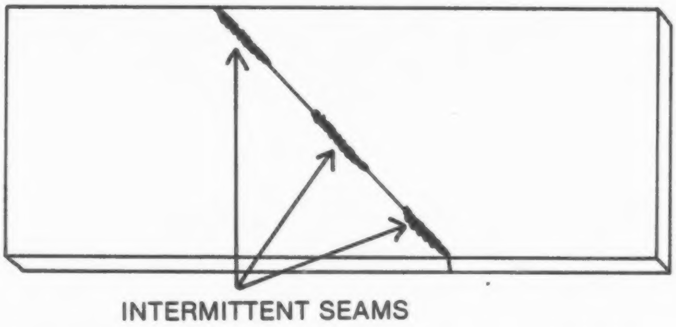
c. Drill or punch hole in outer panel being joined --5/16-inch hole required.

d. Clamp panels together carefully.

e. Allow to cool naturally before any adjacent welds are made.

2. Plug weld to join more than two panels
    - a. Hole punched in all panels except last
    - b. Decreasing diameter of holes -- largest facing welder and smaller holes going away from welder
    - c. The thicker the panel is, the larger the hole should be punched.
    - d. When joining panels of different thicknesses, the thickest panel should be closest to welder.
3. Butt weld (FIG. 1-6)

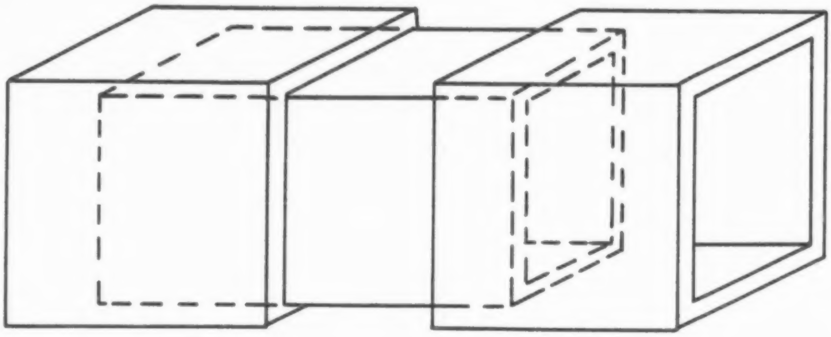
FIGURE 1-6



- a. Panels to be butt welded should be of same thickness and material.
- b. Weld should not be made continuously -- weld no more than 1 3/4-inch seams, allow to cool, then continue with 1 3/4-inch seams until weld is continuous.
- c. When butt welding vertical sections for structural panels, the weld must not be made in a straight vertical line, but should be welded on a diagonal line.

4. Butt joint with insert (FIG. 1-7)

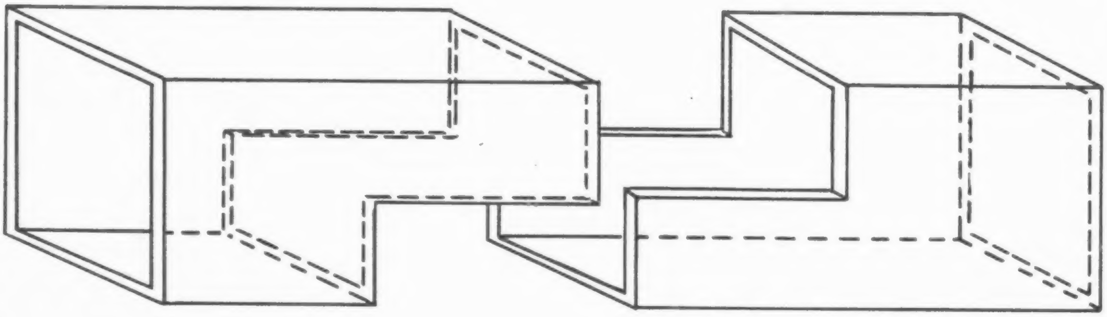
FIGURE 1-7



- a. Used on closed sections -- pillars, rocker panels, body rails
- b. Insert must be built from same material as sections being joined.
- c. Plug welds used to secure insert

5. Offset butt joint (FIG. 1-8)

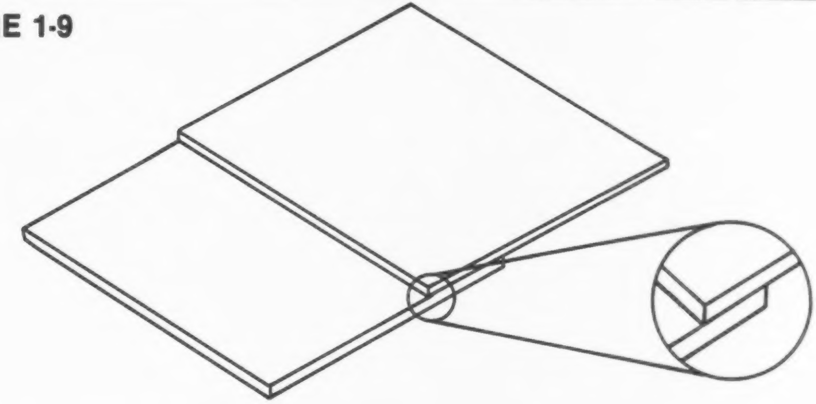
FIGURE 1-8



- a. Used on closed sections
- b. Weld joint must be closed completely.

6. Overlap joint (FIG. 1-9)

FIGURE 1-9



a. Only made in repairs where they replace original factory lap welds or where non-structural panels are involved

b. Should not be used to join more than two thickness of material together

(Note: These structural welds are also covered in Module 7, "Frame-body and unibody construction and repair." Consult that module for specific procedures on structural panel repairs.)

E. Additional guidelines for MIG welding of vehicle panels

1. In all panel welds, holding the panels properly in place is important.

   a. If clamps cannot be employed due to space, sheet metal screws can be used to clamp panels -- after weld is complete remove screws and plug weld resulting holes.

   b. In some cases fixtures for dedicated measuring systems can be use to align panels (See Module 7.)

2. In structural repairs, test welds should be made on scrap parts which duplicate the materials and conditions of the actual weld.

3. The welder settings must be carefully and properly set.

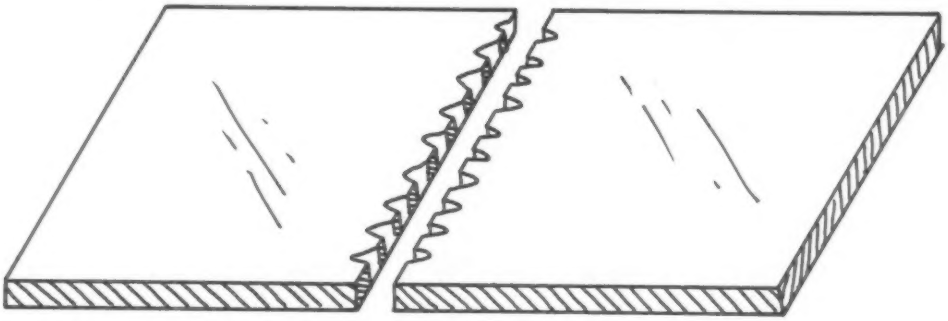
4. In preparing zinc-coated metal for welding, do not grind away the zinc, unless vehicle manufacturer recommends it.

5. I-CAR recommends using wire for panel repairs that exceeds AWS-E-70S-6 and using 75% argon/25% CO_2 mixture shielding gas.

F. Guidelines for welding aluminum

1. Use low amperages
    a. Aluminum has low melting point (1220° to 1250° F).
    b. Aluminum gives no indication through color change that it is about to melt.
2. Clean surfaces thoroughly.
3. Weld quickly and keep tip moving.
4. Notch joining edges when butt-welding aluminum greater than 1/2-inch thick.

FIGURE 1-10



5. Some technicians recommend blue lenses, which assist in seeing the metal during welding operation.

G. Welding high-strength steels

1. Consult vehicle manufacturer's recommendations for heating.
2. Use MIG welder and temperature-indicating crayons.
3. Keep welding tip moving.
4. Heat only for short periods.
5. Allow natural cooling.

H. Using weld-through primers

1. In unibody panel welding, the use of weld-through primers has become critical to maintaining corrosion protection for the weld area.
2. The special primer provides rust protection while not inhibiting the strength of the weld.

3. Weld-through primer is applied to surfaces to be welded in sparing amounts.
4. Consult primer manufacturer for specific recommendations.

(NOTE: A more detailed view of weld-through primers in given in Module 3, "Panel Repairs", Unit VII.)

UNIT III

JOB SHEET #1, LESSON ONE

CONSTRUCT A MIG PLUG WELD

Equipment:

MIG machine with accessories
Personal safety clothing and equipment
Wire to specifications
Shielding gas to specifications
Mild or HSS as selected by instructor
Adjustable wrench
Weld-through primer

Procedure:

		Evaluation:			
		3	**2**	**1**	**N**
1.	Put on protective clothing and equipment and prepare metal for welding by performing JS #4, Unit II, Lesson Two.	___	___	___	___
2.	Drill 5/16-inch hole in top panel to be plug welded.	___	___	___	___
3.	Apply weld-through primer according to primer manufacturer's recommendations and position pieces to be welded with proper clamping.	___	___	___	___
4.	Determine specifications for weld and set up MIG equipment by performing Job Sheet #3, Unit II, Lesson Two.	___	___	___	___
5.	Set wire-feed speed, shielding gas flow and voltage according to specifications from Step Four.	___	___	___	___
6.	Attach ground clamp to workpiece.	___	___	___	___
7.	Turn on machine and adjust the voltage and amperage to approximate settings for wire size and plate thickness.	___	___	___	___
8.	Run test bead and adjust settings if needed.	___	___	___	___
9.	Weld plug weld with a slow circular motion, then have your instructor check your work.	___	___	___	___

Procedure:	**Evaluation:** **3 2 1 N**
10. Shut off wire-feed speed control, set control to zero, then depress gun trigger to relieve shielding gas pressure. Allow ball in flow meter to return to zero.	__ __ __ __
11. Turn off feed-control power switch and then turn off welding machine power supply, then set voltage at zero.	__ __ __ __
Average of above evaluations*	__ __ __ __

(*This average is the evaluation for competencies F6, "Construct a MIG plug weld," and F5 "Use weld-through primers." It is also the evaluation for competency F9 "Weld high strength steel unibody structural components," if HSS unibody components were used.)

UNIT III

JOB SHEET #2, LESSON ONE

CONSTRUCT A MIG CONTINUOUS WELD

Equipment:

MIG machine with accessories
Personal safety clothing and equipment
Wire to specifications
Shielding gas to specifications
Mild or HSS as selected by instructor
Adjustable wrench
Weld-through primer

Procedure:	**Evaluation:** 3	2	1	N
1. Put on personal safety equipment and prepare metal for welding by performing JS #4, Unit II, Lesson Two.	___	___	___	___
2. Apply weld-through primer according to primer manufacturer's recommendations and position pieces to be welded with proper clamping.	___	___	___	___
3. Determine specifications for weld by performing JS #3, Unit II, Lesson Two.	___	___	___	___
4. Set wire-feed speed, shielding gas flow and voltage according to specifications.	___	___	___	___
5. Attach ground clamp to workpiece.	___	___	___	___
6. Turn on machine and adjust the voltage and amperage to approximate settings for wire size and plate thickness.	___	___	___	___
7. Run test bead and adjust settings if needed.	___	___	___	___
8. Weld no more than a two-inch seam, starting in the middle of the workpiece and allow to cool.	___	___	___	___
9. Skip two inches and weld another two-inch seam.	___	___	___	___
10. Skip back over two inches to other side of first seam and weld a two-inch seam.	___	___	___	___

Procedure: **Evaluation:**
3 2 1 N

11. Continue alternating two-inch seams on alternating sides from first seam until edges are reached. ___ ___ ___ ___

12. Return to first gap left next to first and second welded seam and weld gap making sure to close gaps between seams completely. ___ ___ ___ ___

13. Return to second gap left (between first and third seams welded) and close gap. ___ ___ ___ ___

14. Continue alternating between gaps on opposite sides of first seam welded until a continuous weld has been formed, then have your instructor check your work. ___ ___ ___ ___

15. Shut off wire-speed feed control, set control to zero, then depress gun trigger to relieve shielding gas pressure. Allow ball in flow meter to return to zero. ___ ___ ___ ___

16. Turn off feed control power switch and then turn off welding machine power supply, then set voltage at zero. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for Competency F7, "Construct a MIG continuous weld," and F5 "Use weld-through primers." It is also the evaluation for competency F9 "Weld high strength steel unibody structural components," if HSS unibody components were used.)

UNIT III

JOB SHEET #3, LESSON ONE

CONSTRUCT A MIG STITCH WELD

Equipment:

MIG machine with accessories
Personal safety clothing and equipment
Wire to specifications
Shielding gas to specifications
Mild or HSS as selected by instructor
Adjustable wrench
Weld-through primer

Procedure:

		Evaluation: 3	2	1	N
1.	Put on protective clothing and prepare metal for welding by performing Job Sheet #4, Unit II, Lesson Two.	___	___	___	___
2.	Apply weld-through primer according to primer manufacturer's recommendations and position pieces to be welded with proper clamping.	___	___	___	___
3.	Determine specifications for weld by performing JS #3, Unit II, Lesson Two.	___	___	___	___
4.	Set wire-feed speed, shielding gas flow and voltage according to specifications.	___	___	___	___
5.	Attach ground clamp to workpiece.	___	___	___	___
6.	Turn machine on and adjust the voltage and amperage to approximate settings for wire size and plate thickness.	___	___	___	___
7.	Adjust stitch timer to proper settings according to instructor's recommendations.	___	___	___	___
8.	Run test bead and adjust settings if needed.	___	___	___	___
9.	Weld stitch weld continuously and have your instructor check your work.	___	___	___	___
10.	Shut off wire-feed speed control, set control to zero, then depress gun trigger to relieve shielding gas pressure. Allow ball in flow meter to return to zero.	___	___	___	___

Procedure: **Evaluation:**
3 2 1 N

11. Turn off feed control power switch and then turn off welding machine power supply, then set voltage at zero. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for Competency F8 "Construct a MIG stitch weld," and F5 "Use weld-through primers." It is also the evaluation for competency F9 "Weld high strength steel unibody structural components," if HSS unibody components were used.)

UNIT III

JOB SHEET #4, LESSON ONE

PASS A MIG WELD DESTRUCTIVE TEST

Equipment:

MIG machine with accessories
Personal safety clothing and equipment
Wire to specifications
Shielding gas to specifications
Mild or HSS as selected by instructor
Adjustable wrench
Weld-through primer

Procedure:	**Evaluation:** 3	2	1	N
1. Select scrap pieces of metal duplicating conditions of weld you wish to test for.	___	___	___	___
2. Prepare metal for welding by performing Job Sheet #4, Unit II, Lesson Two.	___	___	___	___
3. Apply weld-through primer according to primer manufacturer's recommendations and position pieces to be welded with proper clamping.	___	___	___	___
4. Determine specifications for weld by performing JS #3, Unit II, Lesson Two.	___	___	___	___
5. Set wire-feed speed, shielding gas flow and voltage according to specifications.	___	___	___	___
6. Attach ground clamp to workpiece.	___	___	___	___
7. Turn machine on and adjust the voltage and amperage to approximate settings for wire size and plate thickness.	___	___	___	___
8. Run test bead and adjust settings if needed. *(NOTE: Make a note of the settings and use the same settings for the actual weld, if test weld passes destructive test.)*	___	___	___	___
9. Weld using required technique.	___	___	___	___
10. Have your instructor check your work. Inspect for complete penetration of back side and general weld appearance.	___	___	___	___

Procedure:	**Evaluation:** 3 2 1 N
11. According to equipment available, test weld for strength.	__ __ __ __
12. Shut off wire-feed speed control, set control to zero, then depress gun trigger to relieve shielding gas pressure. Allow ball in flow meter to return to zero.	__ __ __ __
13. Turn off feed control power switch and then turn off welding machine power supply, then set voltage at zero.	__ __ __ __

(NOTE: This job sheet does not evaluate a competency.)

MODULE: WELDING

UNIT III: APPROVED AUTO BODY MIG WELDS

UNIT III TEST

I. Match the type of weld in the left column with its correct illustration in the right column.

_____1. Plug weld

_____2. Butt weld

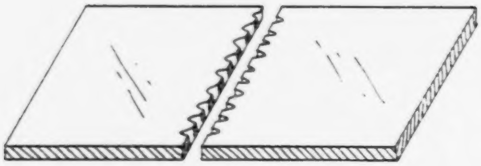
_____3. Butt joint with insert

_____4. Offset butt joint

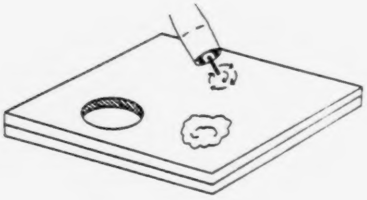
_____5. Overlap joint

_____6. Aluminum butt weld

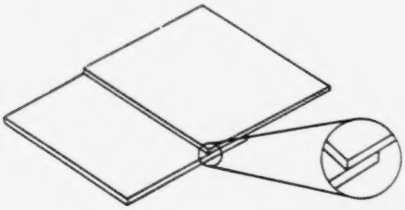
A.



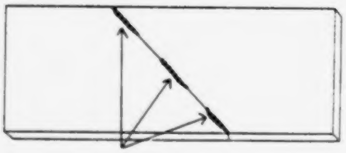
B.



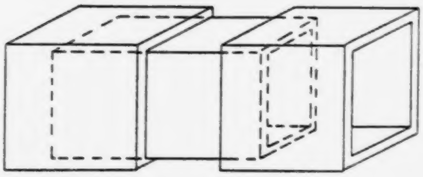
C.



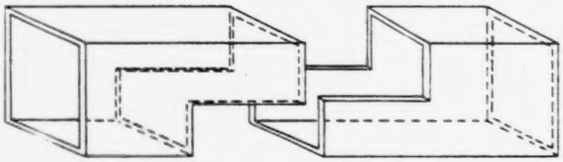
D.



E.



AB.



II. Match the terms in the left column with the corresponding illustration from the right column.

_____7. Flat position

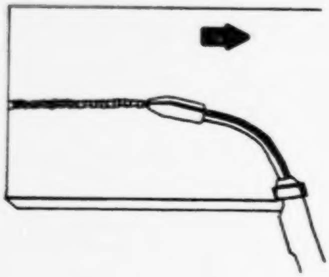
_____8. Vertical down position

_____9. Vertical up position

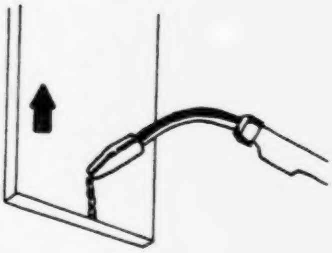
_____10. Horizontal position

_____11. Overhead position

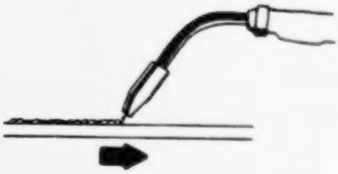
A.



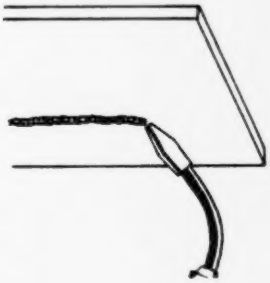
B.



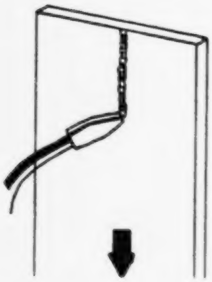
C.



D.



E.



III. Match the definition in the left column with the correct term from the right column.

_____12. Weld which is usually made by welding two-inch seams and leaving two-inch gaps, which are then filled in	A. Plug weld B. Butt joint with insert
_____13. Weld which is made by using an automatic timer setting on MIG machine to allow weld segments to cool	C. Stitch weld D. Zinc E. Test weld
_____14. Provides corrosion protection without inhibiting strength of weld	AB. Overlap joint
_____15. Weld used to replace factory spot welds	AC. Continuous weld AD. Butt weld
_____16. When using this weld on vertical sections it must be welded on a diagonal line	AE. Weld-through primer
_____17. Used on closed sections with plug welds used to secure insert	BC. Z-joint
_____18. Used only where it will replace original factory lap weld or where non-structural panels are involved	
_____19. Weld done on scrap parts duplicating materials and conditions of actual weld	
_____20. Should not be ground away if present	

IV. Select the best answer from the choices listed.

_____21. The reason a continuous weld is made with the gap method or the stitch weld method is to: (a) improve weld strength, (b) keep welder cool, (c) prevent heat distortion, (d) prevent corrosion, (e) prevent whiskers.

_____22. The reason a weld-through primer is used is to: (a) improve weld strength, (b) keep welder cool, (c) prevent heat distortion, (d) prevent corrosion, (e) prevent whiskers.

_____23. When making I-CAR plug welds the size of the hole for the plug weld should be: (a) 1/16-inch, (b) 3/16-inch, (c) 5/16-inch, (d) 7/16-inch, (e) 9/16-inch.

_____24. When using an insert for a butt joint, the insert should be made of: (a) the same material as the sections being joined, (b) aluminum, (c) high-strength steel, (d) mild steel, (e) iron.

_____25. A material which, if present, should not be ground away in preparing a weld is: (a) high-strength steel, (b) aluminum, (c) weld-through primer, (d) zinc, (e) copper.

_____26. I-CAR recommends using which of the following shielding gases for structural repairs: (a) CO_2, (b) 75% argon, 25% CO_2, (c) 75% helium, 25% CO_2, (d) 75% argon, 25% helium, (e) 75% CO_2, 25% argon.

(NOTE: Completion of this unit test with a minimum score of ____ is necessary for the student to receive evaluations on Competencies F5, F6, F7, and F8.)

ANSWERS TO UNIT III TEST

1. B
2. D
3. E
4. AB
5. C
6. A

7. C
8. E
9. B
10. A
11. D

12. AC
13. C
14. AE
15. A
16. AD
17. B
18. AB
19. E
20. D

21. C
22. D
23. C
24. A
25. D
26. B

MODULE: WELDING

UNIT IV: OXYACETYLENE WELDING EQUIPMENT AND SAFETY

UNIT OBJECTIVE

Upon completion of this unit the student should be able to identify oxyaceytylene welding equipment and safety procedures and be able to set up oxyacetylene welding equipment. Mastery will be evidenced through demonstration and by scoring ___% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Match terms with their definitions. (Competency F11, Part I of Unit IV test.)

II. Identify uses of oxyacetylene equipment in auto body. (Competency F11, Part I of Unit IV test.)

III. Identify components of the oxyacetylene welder. (Competency F11, Part I of Unit IV test.)

IV. Identify the construction and operation of the components of the oxyacetylene welder. (Competency F11, Part I of Unit IV test.)

V. Identify the types of welding flames. (Competency F11, Part I of Unit IV test.)

Lesson 2:

I. Identify oxyacetylene welding safety procedures. (Competencies F10, F13, Part II of Unit IV test.)

II. Demonstrate the ability to:

   a. Set up and test oxyacetylene welding equipment. (Job Sheet #1.)

   b. Light and adjust torch. (Job Sheet #2.)

MODULE: WELDING

UNIT IV: OXYACETYLENE WELDING EQUIPMENT AND SAFETY

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

1. Lesson 1: Orientation and Equipment

    a. Information outline

    b. Handouts

        HO#1: Acetylene Flames

    c. Transparency masters

        TM#1: Acetylene cylinder
        TM#2: Welding regulators
        TM#3: Welding torches
        TM#4: Accessories

2. Lesson 2: Safety and Basic Torch Set-up

    a. Information outline

    b. Transparency masters

        TM#1: Safety rules
        TM#2: Safety rules
        TM#3: Safety rules
        TM#4: Cylinder into a rocket
        TM#5: Safety rules
        TM#6: Safety rules
        TM#7: Safety rules
        TM#8: Safety rules
        TM#9: Safety rules
        TM#10: Safety rules

    c. Job sheets

        JS#1: Set up and test oxygen and acetylene equipment
        JS#2: Light and adjust welding torch

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Any of the job sheets can be used to evaluate competency F11. Only one weld need be made.

REFERENCES

1. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

2. Czapskie, George S., et. al. *Auto Body Repair.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1977.

3. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL. 1984.

4. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

5. Walters, Terry, and Walker, Susan. *Automotive Body Repairer.* Curriculum & Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education. Stillwater, OK. 1986.

MODULE: WELDING

UNIT IV: OXYACETYLENE WELDING EQUIPMENT AND SAFETY

LESSON ONE: ORIENTATION AND EQUIPMENT

I. **Terms and definitions**

   A. Acetylene -- Colorless gas with a distinct odor.

   B. Braze welding -- Joining two pieces of metal by melting a brass rod with an oxyacetylene torch.

   C. Heat distortion -- Changes in the shape and size of metals as a result of being exposed to temperatures in excess of the metal's tolerance.

   D. Oxyacetylene cutting -- Using an oxyacetylene welder with a special torch head to cut through metal.

   E. Oxyacetylene welding -- Welding metals using a mixture of oxygen and acetylene as the source of heat.

   F. Oxygen -- Colorless, odorless and tasteless gas, used in combination with acetylene in oxyacetylene welding and cutting.

   G. Purging -- Removing foreign material from oxygen or acetylene lines by cracking the regulator valves briefly before lighting the welder or torch.

   H. PSI -- Pounds per square inch.

   I. Running a bead -- The pattern formed by welded metal in a properly executed weld.

   J. Striker -- A special flint lighter for igniting an oxyacetylene welder or torch.

   (**CAUTION:** *NEVER use anything except a striker to light oxyacetylene equipment.)*

II. **Uses of oxyacetylene equipment in auto body**

   A. Welding

      1. Application declining

      2. Still some application for older vehicles

   B. Cutting

      1. Metal saw recommended on late-model vehicles

      2. May be used to cut away severely damaged sheet metal that will not be repaired or sectioned (as long as their is no significant heat applied to adjacent panels which will be repaired).

C. Heating

1. May be used extensively to relieve stress in working with metals

2. Consult Module 7 "Frame-Body and Unibody Construction and Repair," for techniques in stress relief.

D. Brazing

1. In brazing the metals are not melted together, but joined with a separate melted metal, usually brass.

2. Brazing has very limited application in modern vehicle repair due to the lack of strength of the procedure.

III. Components of the oxyactylene welder (FIG. 1-1, next page)

A. Cylinder truck with safety chain

B. Gas cylinders and components

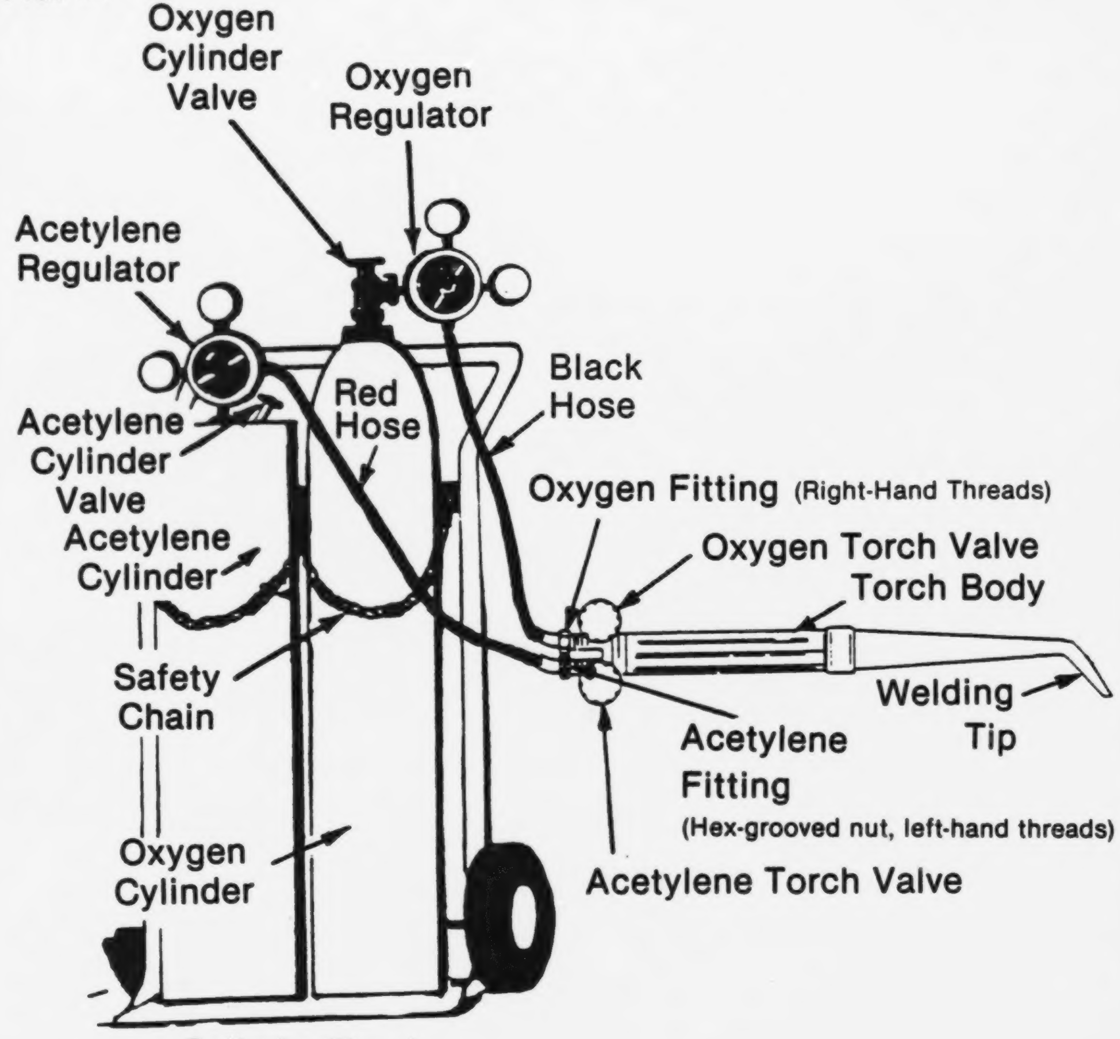
1. Acetylene cylinder
2. Acetylene cylinder valve
3. Acetylene regulator
4. Oxygen cylinder
5. Oxygen cylinder valve
6. Oxygen regulator

C. Hoses

D. Torch body and components

1. Torch body
2. Oxygen fitting (right-hand threads)
3. Acetylene fitting (left-hand threads)
4. Oxygen torch valve
5. Acetylene torch valve
6. Welding tip

FIG. 1-1


Oxygen Cylinder Valve
Oxygen Regulator
Acetylene Regulator
Acetylene Cylinder Valve
Red Hose
Black Hose
Oxygen Fitting (Right-Hand Threads)
Acetylene Cylinder
Oxygen Torch Valve
Torch Body
Safety Chain
Welding Tip
Acetylene Fitting (Hex-grooved nut, left-hand threads)
Oxygen Cylinder
Acetylene Torch Valve
Cylinder Truck

IV. **Construction and operation of components**

A. Oxygen cylinder

1. Wall thickness 5/16-inch

305

2. Double-seated valve

   (CAUTION: *When in use, always have valve open fully.)*

3. Most common sizes
   - a. 80 cu. ft.
   - b. 122 cu. ft.
   - c. 244 cu. ft.
4. Maximum pressure is 2,200 psi at 70° F.
5. Have protective cap over valve connection.
6. Gas is sold in cubic feet.
7. For safety there are safety plugs which melt at 220° F.

B. Acetylene cylinder

1. Filled--porous material (asbestos, charcoal, and balsa wood)

   (CAUTION: *Acetylene is unstable and explosive above 15 psi in a free state.)*

2. Single seat valve

   (CAUTION: *Never open acetylene cylinder valve more than a half turn. Never remove key handle from valve. In case of an emergency, turn off the valve.)*

3. Most common sizes
   - a. 200 cu. ft.
   - b. 300 cu. ft.
4. Maximum pressure is 250 psi at 70° F.
5. Has a protective cap over valve connection
6. Gas is sold in pounds.
7. Safety plugs melt at 220° F.

C. Regulators

1. Single stage--reduces cylinder pressure to working pressure in one step.
2. Double stage--reduces cylinder pressure to working pressure in two steps.
   - a. First stage--2,200 psi to 250 psi
   - b. Second stage--250 psi to working pressure at torch

3. Oxygen regulator
    a. Right-handed threads
    b. Gauge--graduated to 3000 psi

       (Note: Use 12 to 15 psi for sheet metal.)
4. Acetylene regulator
    a. Left-handed threads
    b. Gauge--graduated to 15 psi

D. Hoses
1. Oxygen
    a. Color--green or black
    b. Connection--right-handed threads
2. Acetylene
    a. Color--red
    b. Connection--left-handed thread and groove cut in the nut

E. Welding Torch
1. Equal pressure--gases are mixed in torch nozzle.
    a. Body
    b. Hand valves
    c. Mixing chamber
    d. Tips
2. Amount of gas in mixer
    a. Gas pressure from regulator
    b. Torch valve opening

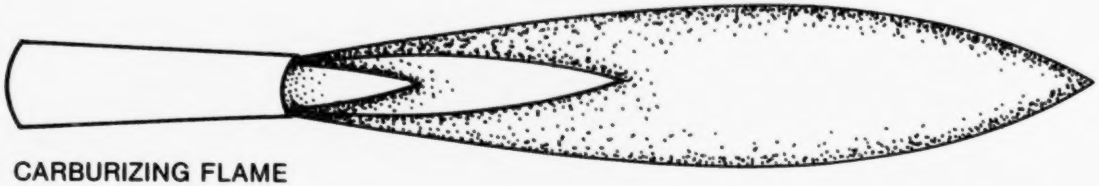
F. Welding tips
1. Size--tip orifice
    a. Size of flame
    b. Amount of heat

        - c. Numbered for size (0 to 15 number range; the larger the number the larger its tip orifice.)
    - 2. Maintenance
        - a. Clean--tip cleaner or twist drill
        - b. Never ream or file.

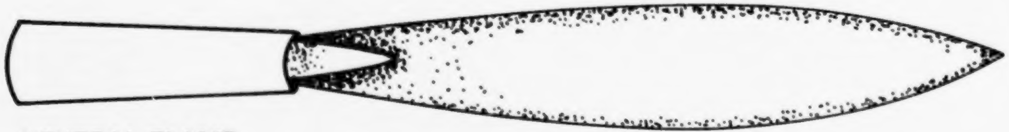
V. Types of welding flames (Handout #1)

- A. Carburizing--excess of acetylene gas in the oxygen mixture
    - 1. Parts of flame
        - a. Inner cone (whitish)
        - b. Feather
        - c. Envelope
    - 2. Use
        - a. Non-ferrous metals
        - b. Body soldering
- B. Neutral flame--equal parts of acetylene and oxygen
    - 1. Parts of the flame
        - a. Cone
        - b. Envelope
    - 2. Use
        - a. Mild steel
        - b. Heating metal
- C. Oxidizing flame--more oxygen than acetylene gas being consumed
    - 1. Parts of the flame
        - a. Cone is pointed.
        - b. Envelope is short and bushy.
    - 2. Use
        - a. Adds excess oxygen to the weld joint
        - b. Weakens the weld

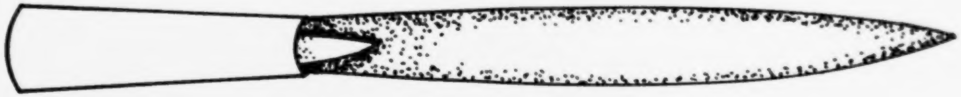
OXYACETYLENE FUSION WELDING FLAMES



CARBURIZING FLAME

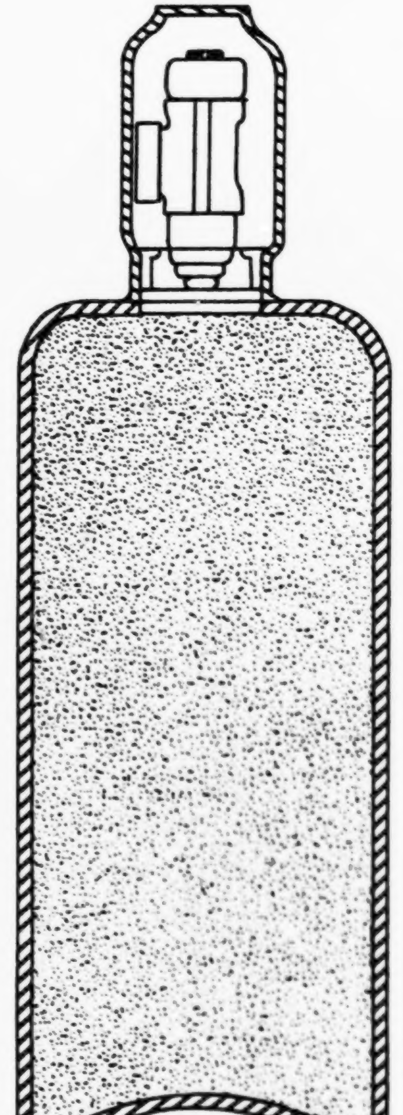


NEUTRAL FLAME



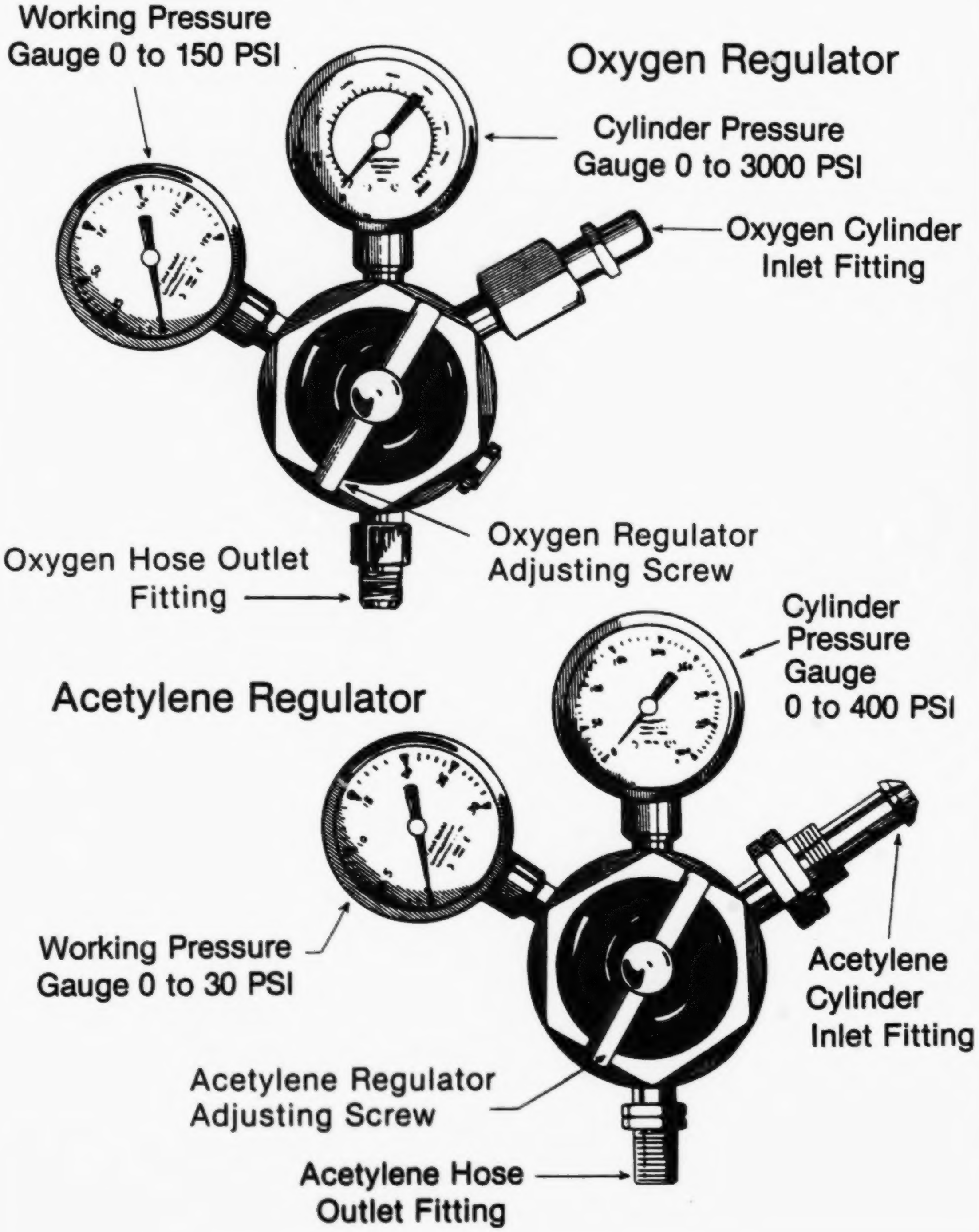
OXIDIZING FLAME

Acetylene Cylinder



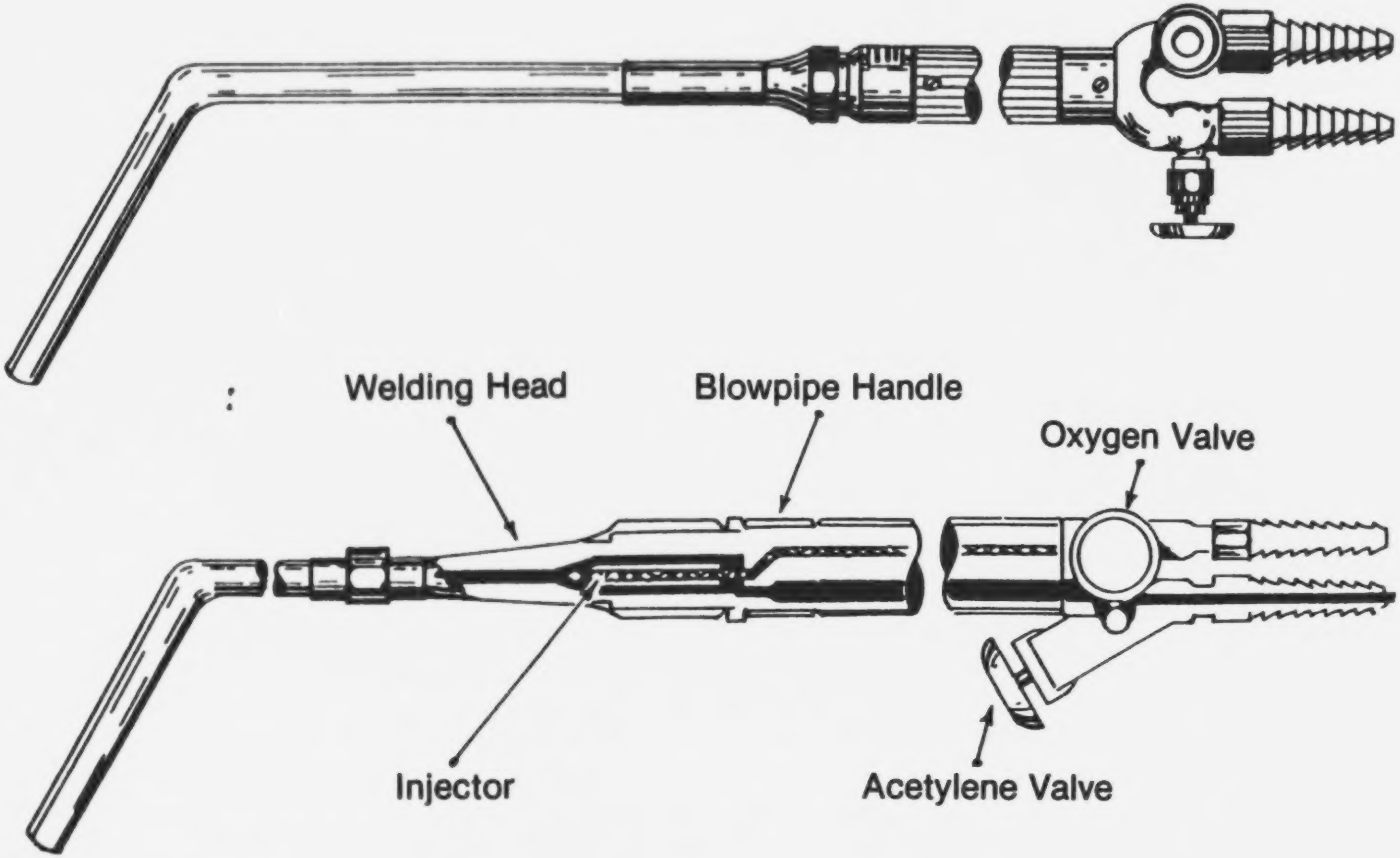
Cross-section of acetylene bottle
with porous filler material

Welding Regulators


Working Pressure
Gauge 0 to 150 PSI
Oxygen Regulator
Cylinder Pressure
Gauge 0 to 3000 PSI
Oxygen Cylinder
Inlet Fitting
Oxygen Hose Outlet
Fitting
Oxygen Regulator
Adjusting Screw
Cylinder
Pressure
Gauge
0 to 400 PSI
Acetylene Regulator
Working Pressure
Gauge 0 to 30 PSI
Acetylene
Cylinder
Inlet Fitting
Acetylene Regulator
Adjusting Screw
Acetylene Hose
Outlet Fitting

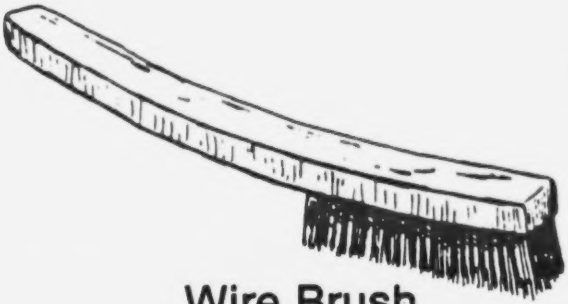
Welding Torches

Injector Type

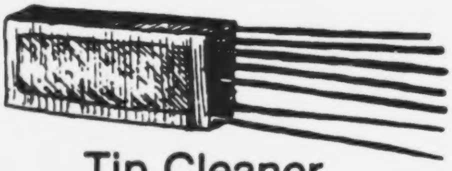

Welding Head
Blowpipe Handle
Oxygen Valve
Injector
Acetylene Valve

TM 3

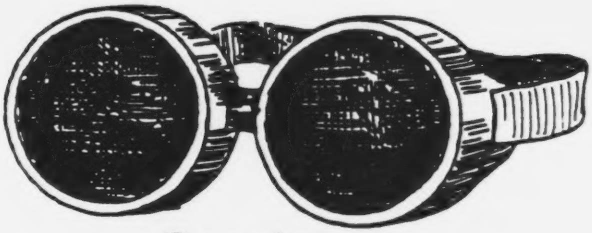
Accessories



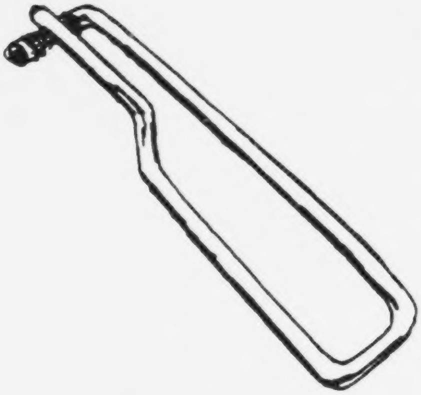
Wire Brush



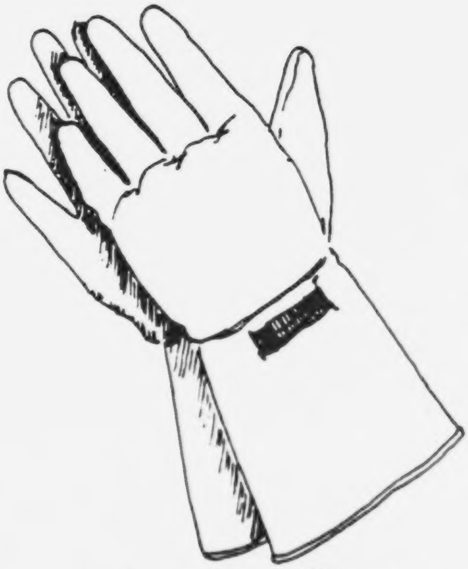
Tip Cleaner



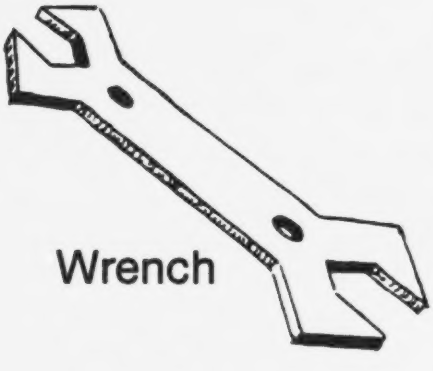
Goggles



Spark Lighter



Leather Gloves



Wrench

MODULE: WELDING

UNIT IV: OXYACETYLENE WELDING SAFETY AND EQUIPMENT

LESSON TWO: SAFETY AND BASIC TORCH SET-UP

I. **Safety rules for oxyacteylene equipment**

(**CAUTION:** *Safety is extremely important is using oxyacteylene equipment. The list of dangers is long. Great care must always be taken by those operating this equipment. Failure to follow safety rules in using oxyacteylene equipment for welding or cutting greatly increases the danger of burns, explosions, or eye injuries. At the same time, oxyactylene equipment is very safe when safety rules are followed.)*

A. Always use proper welding goggles

  1. Tinted--green or brown

  2. Shade--1 to 14 number range

    a. Smaller number--darker tint

    b. Average tint is #10 lens

B. Always use proper protective clothing and equipment.

  1. Use clean, heavy clothing with no cuffs on the pants and flaps over the shirt pockets. The collars and sleeves should be buttoned.

  2. Use heavy leather boots, or steel-toed leather boots.

C. General safety rules

  1. Always be aware of the danger of sparks.

  2. Always be aware of the danger of molten metal.

  3. Always be aware of the danger of light intensity.

D. Safety in lighting a torch

  1. Always stand to the side of an oxygen regulator when the valve is opened.

  2. Always check to see that the pressure-adjusting screw is released before opening the cylinder valve.

  3. *Slowly* open the cylinder valves: oxygen all the way, acetylene from 1/4 to 1/2 turn.

  4. Never allow excess gas to escape into the room.

  5. Never light torch with matches or lighter. Use a striker.

E. Safety for gas cylinders

1. Shipping gas cylinders

   a. Upright standing position

   b. Secured--tightly

   c. Protective caps--in place at all times

   d. Cylinder valves--closed at all times

   e. Ventilation

   (CAUTION: *Acetylene can gather in pockets of gas which can cause an explosion.)*

2. Storing gas cylinders

   a. Do not store near open flame.

   b. "No Smoking" in storage area.

   c. Ventilated area

   d. When empty, mark "MT" in chalk on cylinder.

   e. Secure cylinder

   f. Protective caps in place

   g. Cylinder valves closed

   h. Upright position

3. Handling gas cylinders

   a. Move only with protective caps in place.

   b. Do not drop or knock cylinders around.

   c. Never tamper with safety devices or markings on a cylinder.

   d. Never use a hammer or wrench to open a cylinder valve.

   e. Make sure you can handle cylinder before attempting to move it.

   f. Leave them secure until ready to move.

   g. Secure when not being moved.

   h. Always move gas cylinder by tilting a little toward you and roll on bottom edge of cylinder with cylinder in upright position.

   (CAUTION: *Do not tilt cylinder too far over center; it may cause cylinder to drop.)*

i. A cylinder will turn into a deadly rocket if the top valve is accidentally knocked off.

F. Gas welding safety rules

1. Never allow oil or grease to come in contact with oxygen under pressure.

   (Note: No lubrication of apparatus is necessary.)

2. Never use oxygen as a substitute for compressed air or as a source of pressure.

3. Before starting to weld or cut, make certain there is no flammable material nearby.

4. Always wear goggles when working with a lighted torch.

5. Always use the proper size tip and proper gas pressures.

6. Be sure to keep a clear space between cylinders and work area.

7. Do not use matches for lighting acetylene torches.

   ***(CAUTION:** Hand burns may result from this practice.)*

8. Do not relight flames on hot work section in a pocket or a small, confined space.

   ***(CAUTION:** Acetylene gas gathers in one spot.)*

9. Never use acetylene at pressure above 15 PSI.

10. Never release acetylene where it might cause a fire or explosion.

11. Always see that the hose is securely connected before using equipment.

12. Do not handle a torch with its hose on regulator or cylinder valves.

13. Do not experiment with regulators or torches and do not alter them in any way.

G. Precautions for welding, cutting and heating.

1. It is unsafe to feed oxygen from a cylinder into a confined space.

   ***(CAUTION:** Oxygen supports combustion.)*

2. Arrange for good ventilation when welding on brass, bronze or galvanized materials.

   ***(CAUTION:** Some of the gases given off are poisonous.)*

3. When cutting iron or steel coated with lead or paint containing lead, always wear a suitable airline mask.

4. Use particular caution when welding or cutting in dusty or gassy locations.

   *(***CAUTION:** *Dust can explode.)*

H. Welding and cutting container precautions.

1. Do not weld or cut on containers which have held a flammable substance unless they have been thoroughly cleaned and safeguarded.

2. Protect cylinders, hose, legs, and feet when flame-cutting.

3. Avoid dropping stud ends or welding rods on floor.

4. Wear clothing suitable for the kind of work being done.

   *(***CAUTION:** *Do not wear oily or greasy clothes.)*

5. Adjust clothing, where necessary, to keep out flying sparks and slag.

   *(***CAUTION:** *Keep sleeves and collars buttoned and eliminate cuffs.)*

I. Preventing fires

1. Never use cutting or welding torches where sparks or an open flame of any kind may be a hazard.

2. Take cutting or welding work that can be moved to a location where there will be no possibility of starting fires.

3. If the work cannot be moved, materials that burn easily should be taken away to a safe distance if possible.

4. If flammable materials cannot be moved use sheet metal guards, or similar protection to keep sparks close to the work area.

5. Before starting to cut off a piece of stud or iron, make sure it will not drop where there is any possibility of starting a fire.

   (NOTE: A metal pail with a little water in it will help prevent this hazard.)

6. Use the correct oxygen pressure when cutting.

7. Store extra cylinders away from main work areas.

8. Be ready to put out fires promptly with fire extinguishers, pails of water, water hose or sand.

9. Check jobs a half-hour later for possible fires.

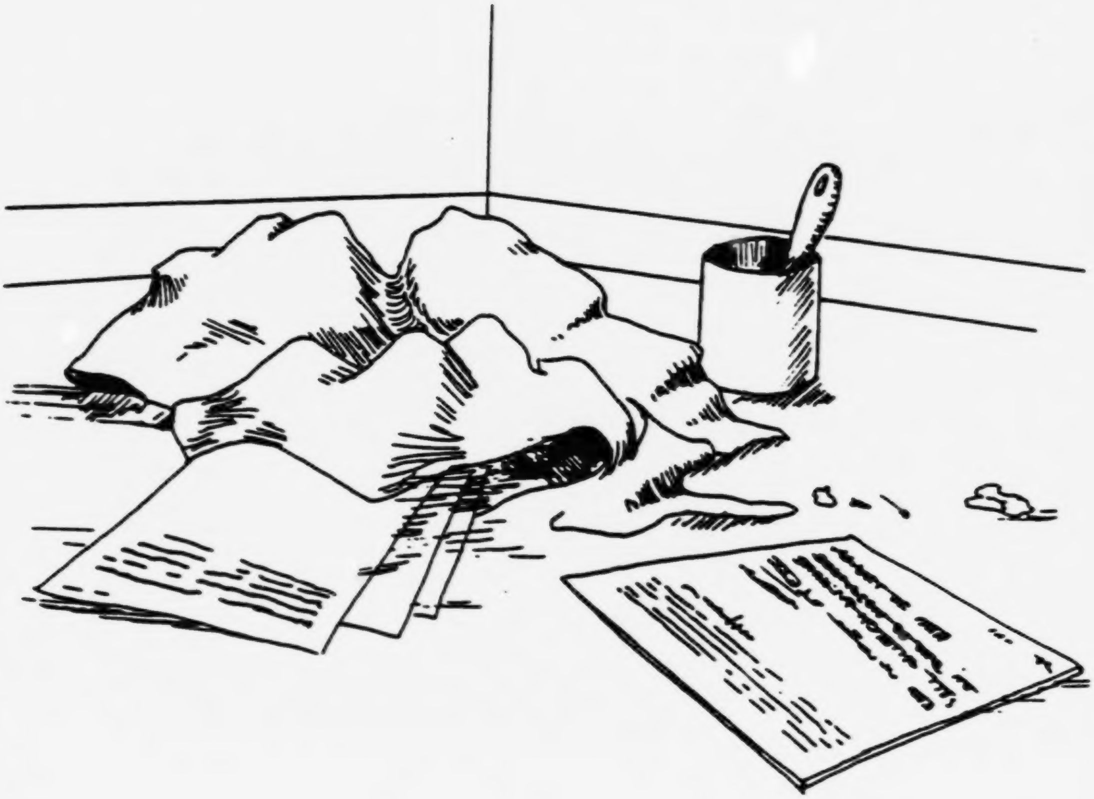
J. Flashback--occurs when flame goes inside the torch (makes hissing or squealing sound).

   1. Causes
      a. Oxygen valve closed first
      b. Insufficient gas pressure for size of tip
   2. Safety--check connection and valves for leaks.

K. Backfire--flame goes out due to improper use of the torch (makes loud snap or pop)

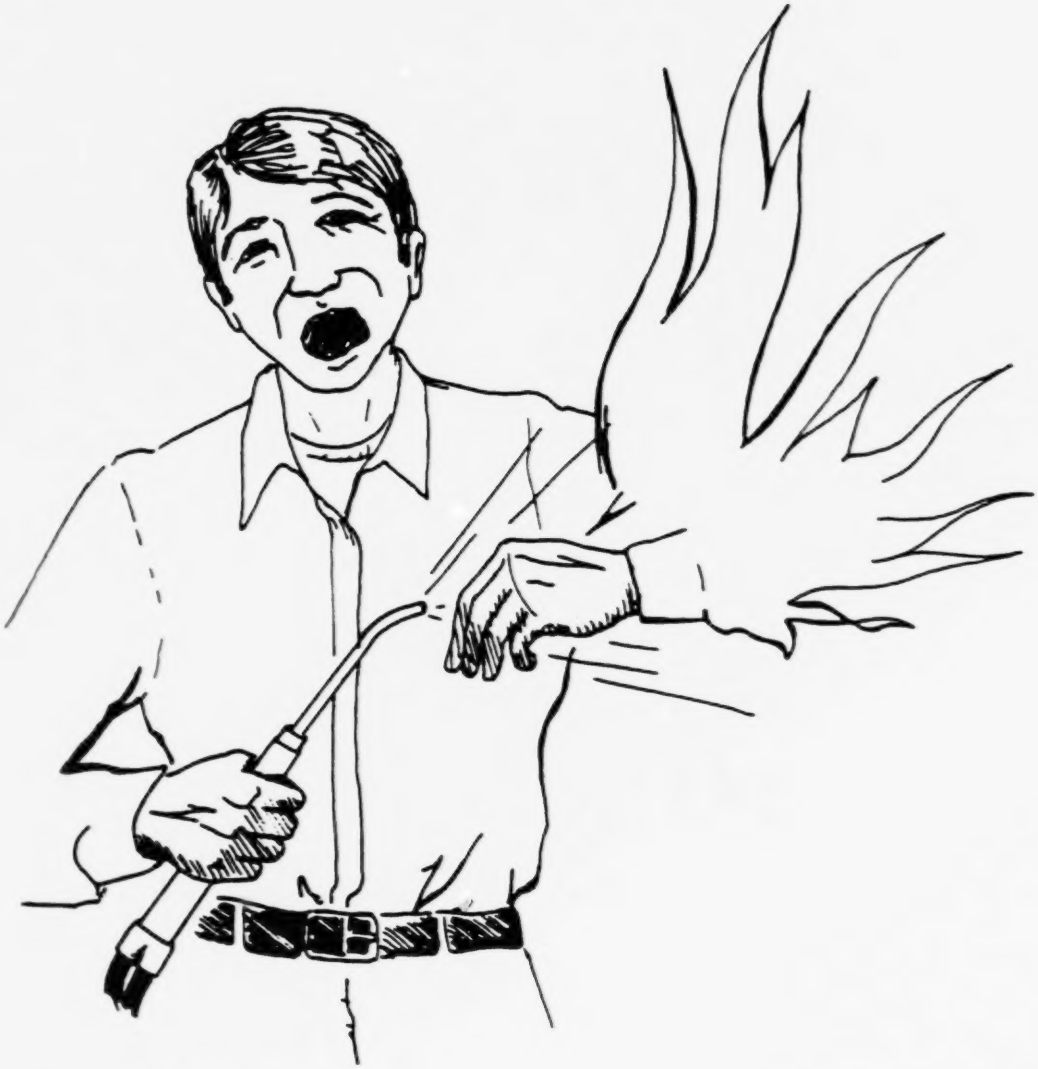
   1. Causes
      a. Tip touching the work
      b. Overheated or dirty tip
      c. Lower than recommended gas pressure
      d. Loose torch head or tip
      e. Poor seal between the torch body and mixing chamber
   2. Safety--check connection and valves for leaks.

Safety Rules



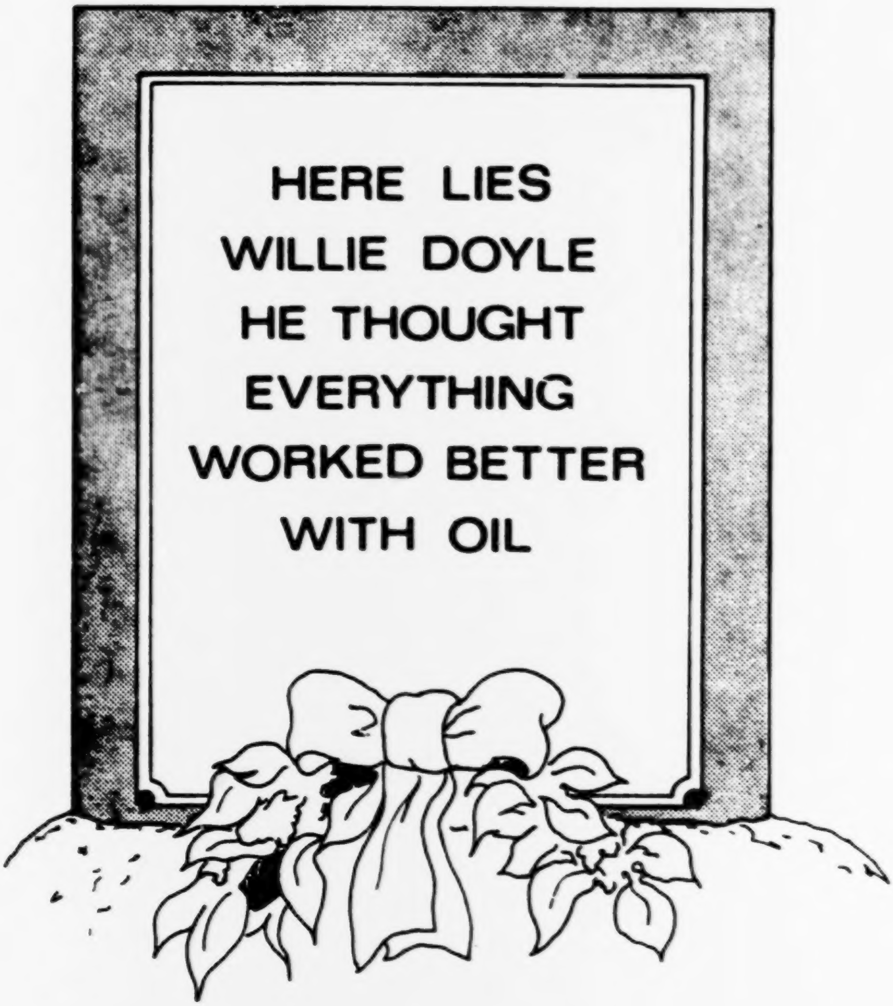
Keep heat, flames, and sparks away from combustibles.

Safety Rules



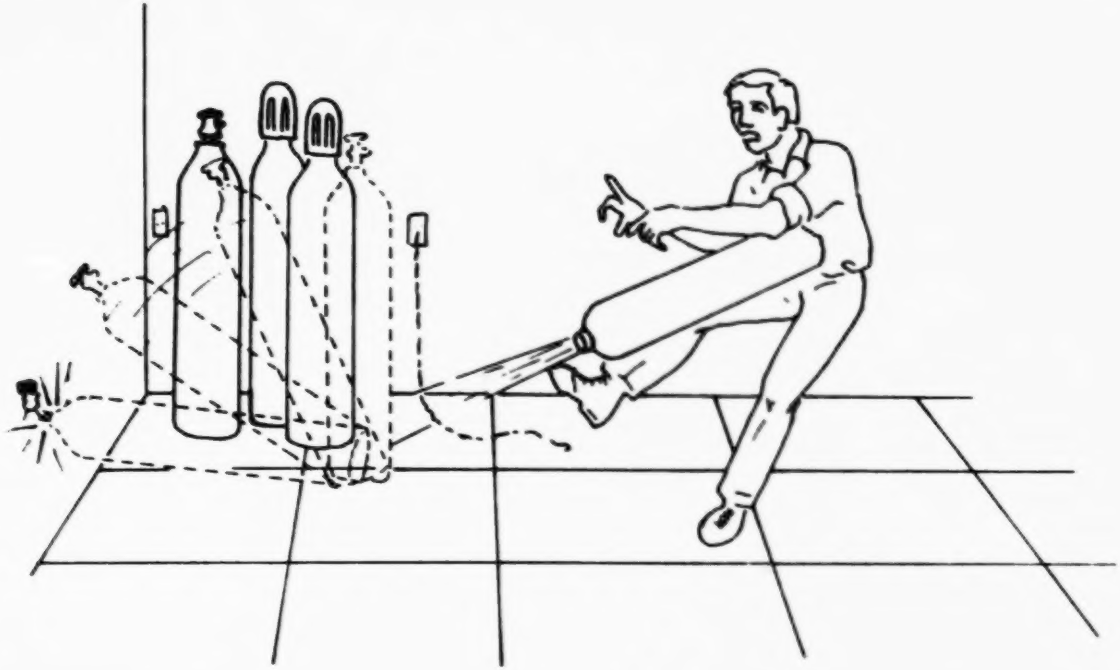
Do not use OXYGEN
as a substitute for COMPRESSED AIR.

Safety Rules


HERE LIES
WILLIE DOYLE
HE THOUGHT
EVERYTHING
WORKED BETTER
WITH OIL

NEVER use oil on regulators, torches, fittings, or other equipment in contact with OXYGEN.

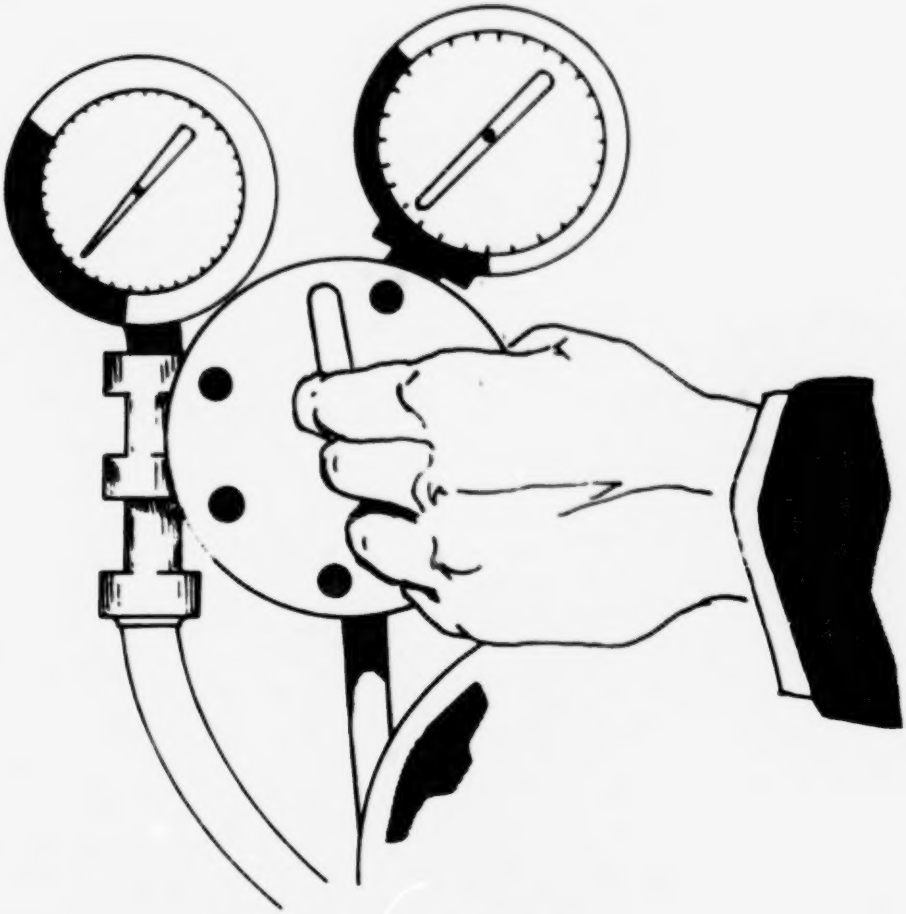
Safety Rules



A standard 250 cu. ft. cylinder pressurized to 2500 PSI can, if a cylinder valve is broken off, become a rocket attaining a speed of 34 MPH in one-tenth of a second after venting from the broken cylinder connection.

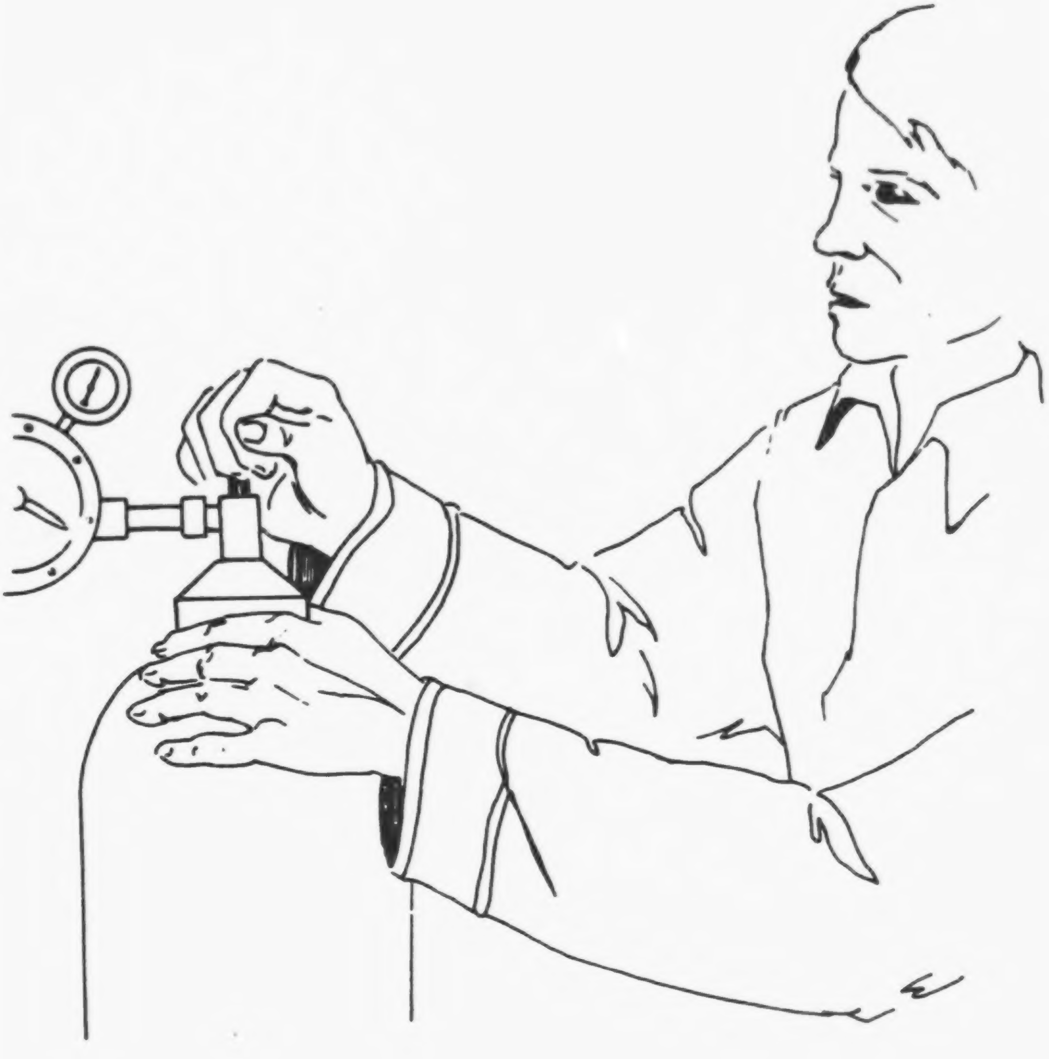
TM 4

Safety Rules



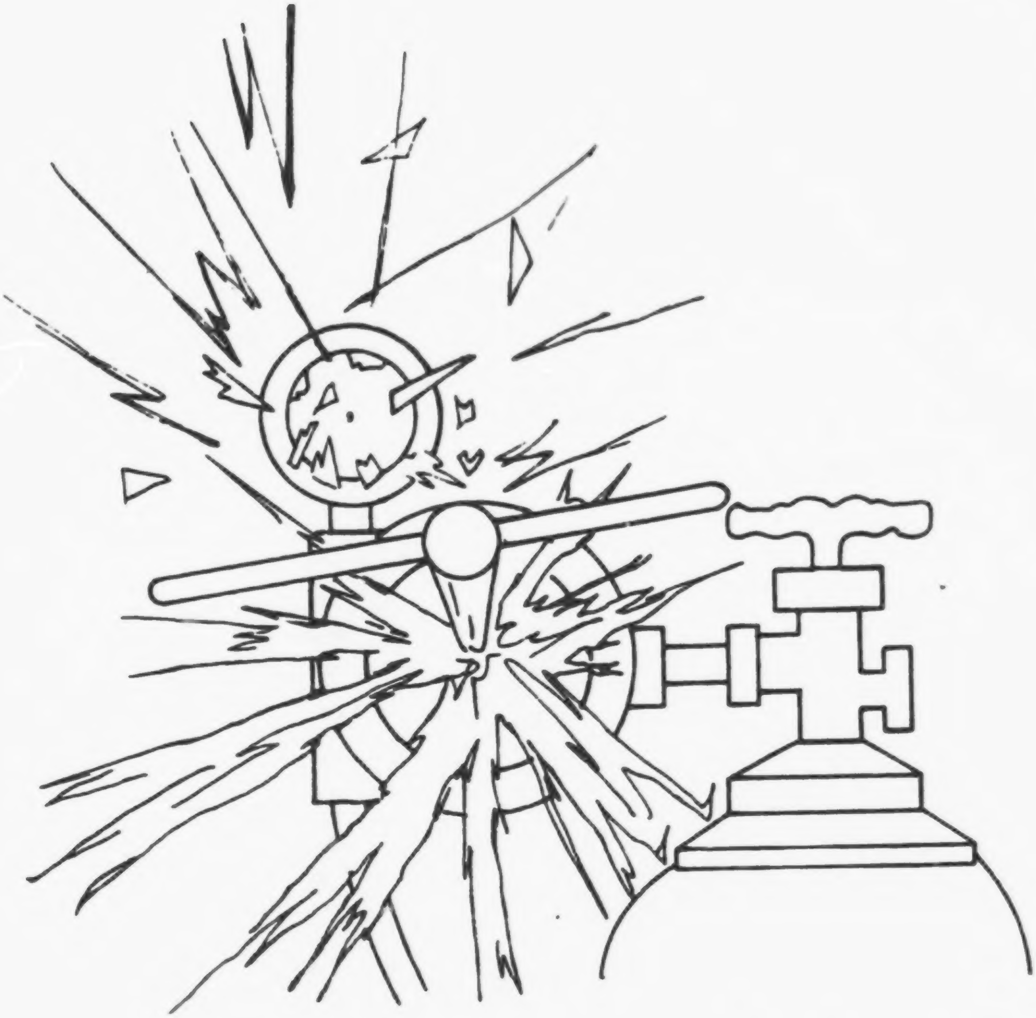
Release adjusting screw on regulators before opening cylinder valves.

Safety Rules



Stand to one side of regulator when opening cylinder valve.

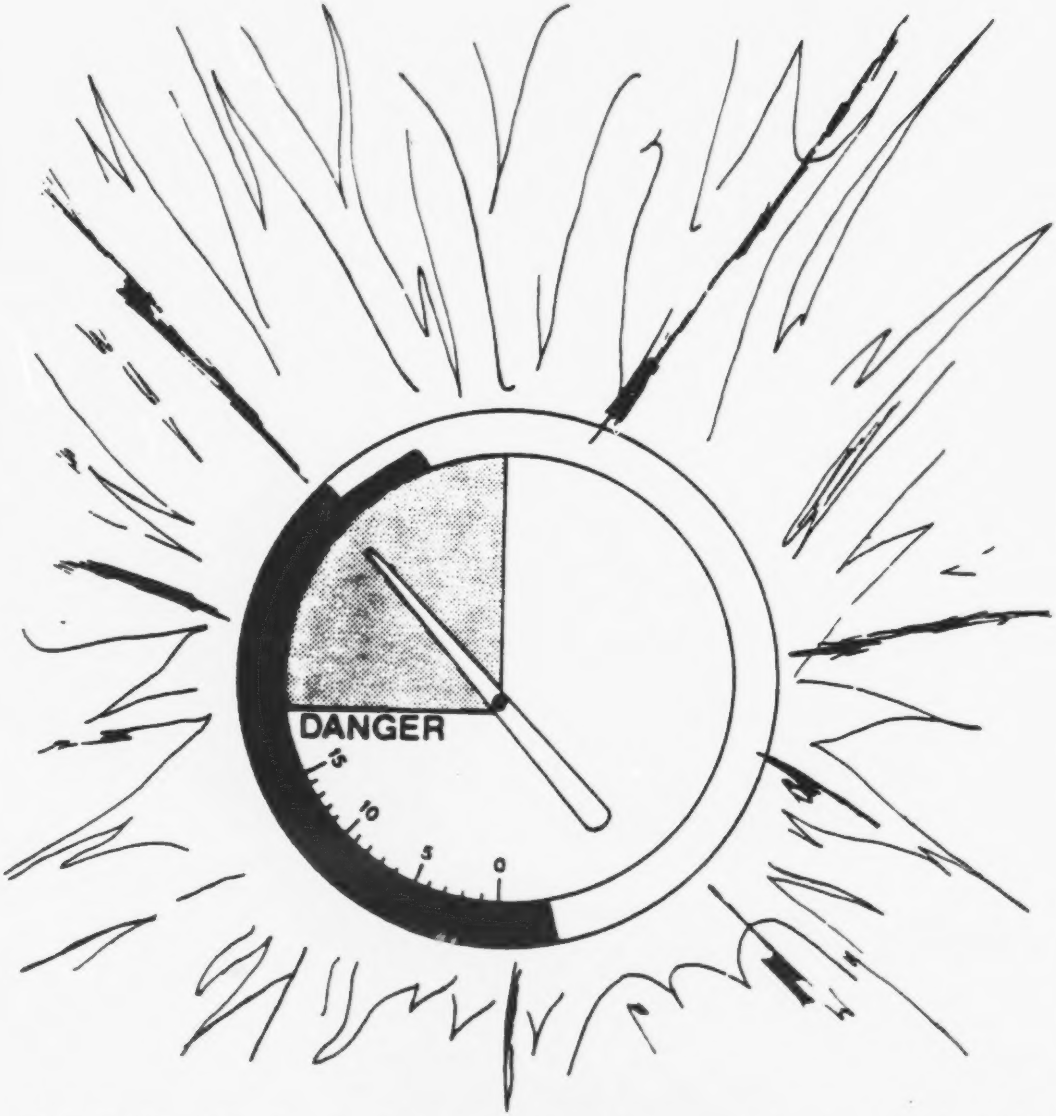
Safety Rules



Open cylinder valves S-L-O-W-L-Y.

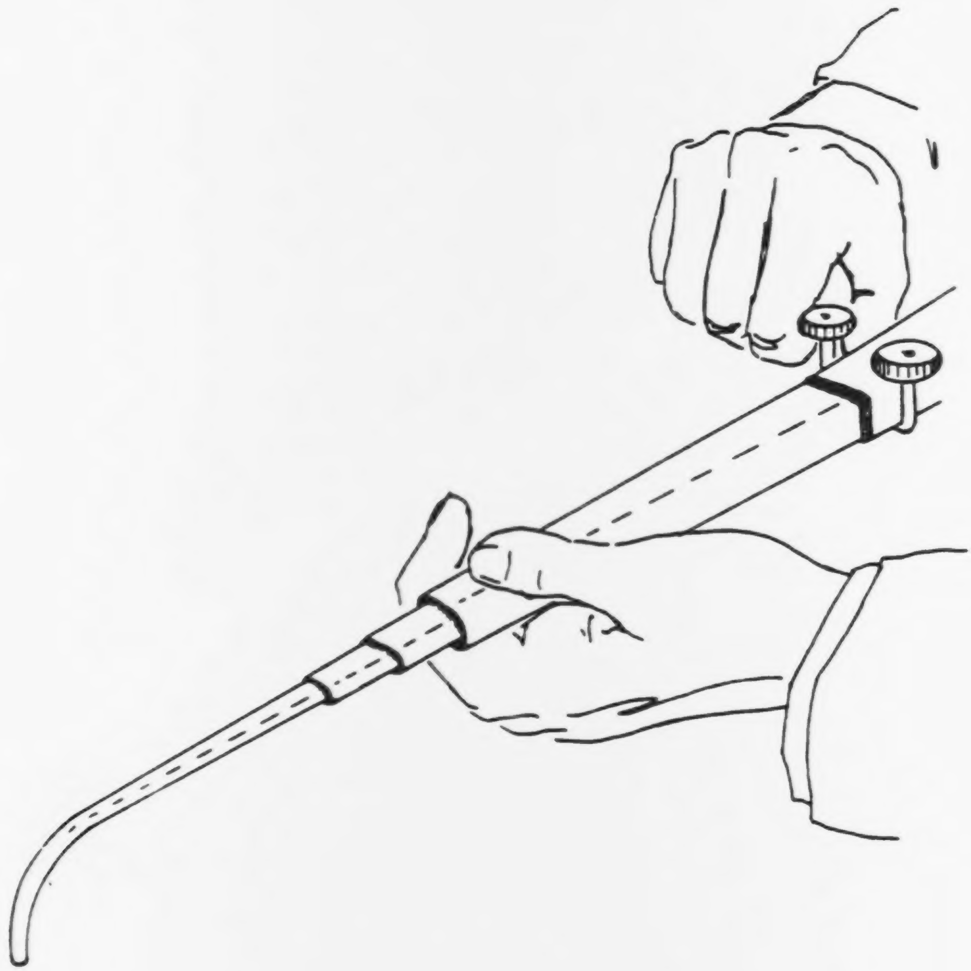
TM 8

Safety Rules


DANGER
15
10
5
0

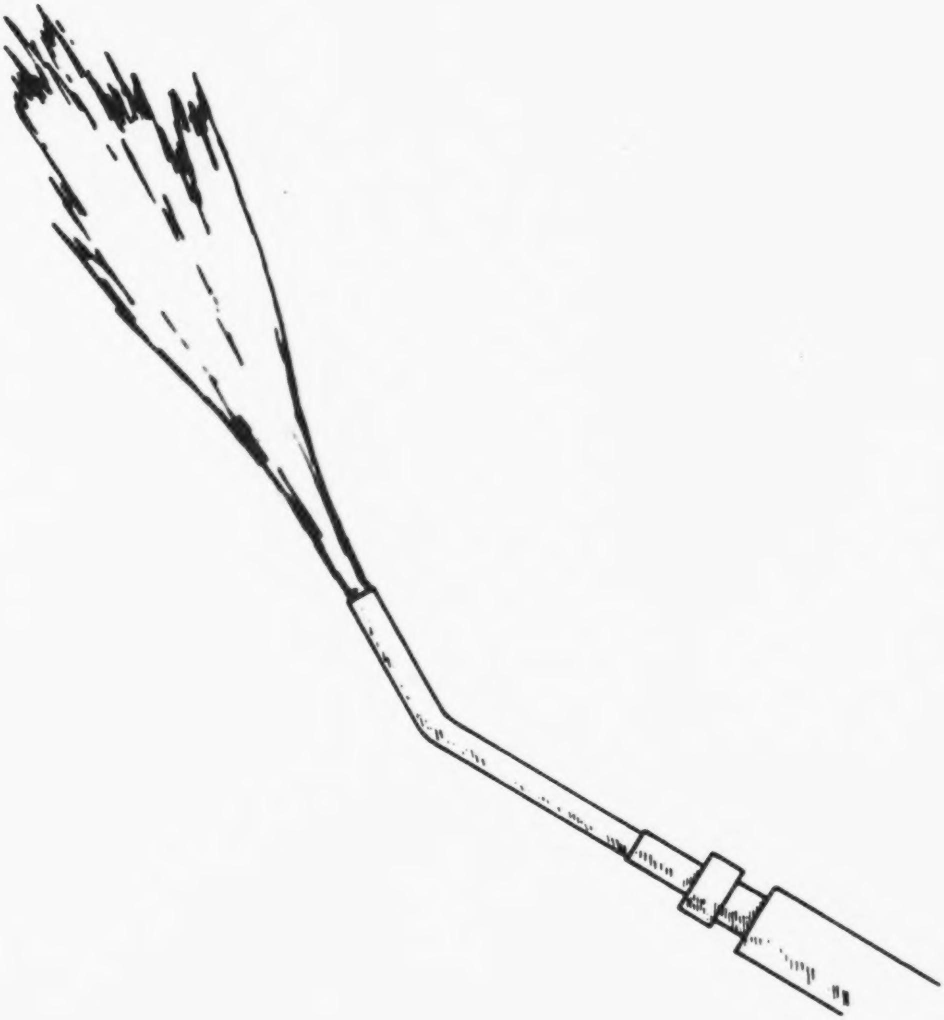
Do not use or compress acetylene (in free state) at pressures higher than 15 PSI.

Safety Rules



Purge oxygen and fuel gas passages (individually) before lighting torch.

Safety Rules



Light acetylene before opening oxygen valve on torch.

UNIT IV

JOB SHEET #1, LESSON TWO

SET UP AND TEST OXYGEN AND ACETYLENE EQUIPMENT

Equipment:

Acetylene cylinder with wrench
Oxygen cylinder
Oxygen regulator
Acetylene regulator
Hoses
Welding torch and attachments
Friction lighters
Welding goggles

Procedure:

Evaluation:
3 2 1 N

1. Secure cylinder with a safety chain and remove the cylinder valve protecting caps. ___ ___ ___ ___

2. Open and close the cylinder valves quickly; this is called "cracking." ___ ___ ___ ___

   (**CAUTION:** *Be sure that the cylinder valve opening is not pointing toward anyone. Keep it away from any open flame. Stand to one side while cracking.)*

3. Check the cylinder valve and the regular threads for damage and attach regulator to cylinder with wrench. ___ ___ ___ ___

4. Turn regulator pressure adjusting screw counter-clockwise until loose, then open the cylinder valve slowly. Then turn the pressure adjusting screws until a small amount of gas flows. ___ ___ ___ ___

   (**CAUTION:** *Do not stand in front of regulator gauges when turning on cylinder valve.)*

5. Attach the oxygen and acetylene hoses to regulators. ___ ___ ___ ___

   (Note: Oxygen hose is green or black and has right-hand threads; the acetylene hose is red and has left-hand threads.)

Procedure: **Evaluation:**
3 2 1 N

6. Clean oxygen and acetylene hoses with cylinder gas, then attach welding torch. ___ ___ ___ ___

   *(**CAUTION:** Acetylene hose connections always have left-hand threads and oxygen hose connections have right-hand threads.)*

7. Attach the welding tip to the torch. ___ ___ ___ ___

8. Open the oxygen cylinder valve and acetylene cylinder valve. ___ ___ ___ ___

   *(**CAUTION:** Open oxygen valve all the way and acetylene valve 1/2 turn or less.)*

9. Close torch valves and adjust pressure to 10 psi on each hose. ___ ___ ___ ___

10. Apply soap and water solution to all connections. ___ ___ ___ ___

    *(**CAUTION:** Apply soapy water with a brush to test for leaks. Under no circumstances should any other means be used for this operation. Use* Ivory® *or another soap free of oils.)*

11. Tighten any connection where gas bubbles appear. ___ ___ ___ ___

    *(**CAUTION:** Do not use any equipment that is leaking gas.)*

Average of above evaluations* ___ ___ ___ ___

(*This average will be transferred to Job Sheet #2.)

UNIT IV

JOB SHEET #2,LESSON TWO

LIGHT AND ADJUST WELDING TORCH

Equipment:

Oxygen cylinder
Acetylene cylinder
Oxygen and acetylene regulator
Hoses
Welding torch
Friction lighter
Welding goggles

Procedure:	Evaluation: 3	2	1	N
1. Perform Job Sheet #1, Lesson Two, to set up equipment.	___	___	___	___
2. Close needle valves on the torch and open oxygen regulator to 20 psi and acetylene to 12 psi. ACETYLENE NEVER OVER 15 PSI.	___	___	___	___
3. Put on goggles and hold torch away from flammable objects.	___	___	___	___
4. Open acetylene needle valve 3/4-turn and hold sparklighter one inch away from torch tip and ignite with tip facing downward. DO NOT USE ANYTHING EXCEPT A SPARKLIGHTER.	___	___	___	___
5. Open oxygen needle valve until a well-defined cone appears near tip. A bluish cone should be faintly luminous (neutral flame).	___	___	___	___
6. Close acetylene needle valve, then close close oxygen needle valve.	___	___	___	___
7. Close both oxygen and acetylene cylinder valves, then open both needle valves and drain line pressure.	___	___	___	___
8. Close both needle valves, then close pressure screws on both regulators.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This job sheet does not evaluate a competency. It is for practice only. The evaluation for Competency F11, "Set up and use equipment for oxyacetylene welding," is from Unit V.)

MODULE: WELDING

UNIT IV: OXYACETYLENE WELDING SAFETY AND EQUIPMENT

UNIT IV TEST

PART I—EQUIPMENT AND PROCEDURES

I. Match the term in the right column with the definition in the left column.

_____1. Colorless gas with a distinct odor.

_____2. Joining two pieces of metal by melting a brass rod.

_____3. Changes in the shape and size of metals due to high temperatures.

_____4. Using oxygen and acetylene to cut through metal.

_____5. Using oxygen and acetylene to fuse metals together.

_____6. Colorless, odorless and tasteless gas.

_____7. Removing foreign material from gas lines by cracking regulator valves before lighting torch.

_____8. The pattern formed by melted metal in a properly executed weld.

_____9. On late-model vehicles the recommended method of cutting off parts.

_____10. A vehicle repair activity for which an oxyacetylene torch is often used on late-model vehicles.

A. PSI
B. Oxygen
C. Zinc
D. Brazing
E. Oxyacetylene welding
AB. Oxyacetylene cutting
AC. Metal saw
AD. Acetylene
AE. Bead
BC. Heat distortion
BD. Stress relief
BE. Purging

II. Select the best answer from the choices listed.

_____11. The pressure in pounds per square in inside an oxygen cylinder is: (a) 15, (b) 50, (c) 250, (d) 2,200, (e) 10,000.

_____12. The pressure in pounds per square in inside an acetylene cylinder is: (a) 15, (b) 50, (c) 250, (d) 2,200, (e) 10,000.

_____13. When in use an oxygen cylinder value must be opened all the way because: (a) you need all the pressure, (b) it has a single-seat valve, (c) it has a double-seat valve, (d) it has a triple-seat valve, (e) you have to purge the lines.

_____14. When in use, an acetylene cylinder valve must never be opened more than one-half turn because: (a) you don't need all the pressure, (b) it has a single-seat valve, (c) it has a double-seat valve, (d) it has a triple-seat valve, (e) you have to purge the lines.

_____15. Acetylene is unstable and explosive in a free state if it is above: (a) 5 psi, (b) 10 psi, (c) 15 psi, (d) 30 psi, (e) 2200 psi.

_____16. An oxygen regulator has: (a) right-hand threads and is graduated to 3000 psi, (b) right-hand threads and is graduated to 250 psi, (c) right-hand threads and is graduated to 15 psi, (d) left-hand threads and is graduated to 3000 psi, (e) left-hand threads and is graduated to 15 psi.

_____17. An acetylene regulator has: (a) right-hand threads and is graduated to 3000 psi, (b) right-hand threads and is graduated to 250 psi, (c) right-hand threads and is graduated to 15 psi, (d) left-hand threads and is graduated to 3000 psi, (e) left-hand threads and is graduated to 15 psi.

_____18. An oxygen hose has: (a) right-hand threads and is colored green or black, (b) right-hand threads and is colored red, (c) right-hand threads and is colored blue, (d) left-hand threads and is colored red, (e) left-hand threads and is colored green or black.

_____19. An acetylene hose has: (a) right-hand threads and is colored green or black, (b) right-hand threads and is colored red, (c) left-hand threads and is colored blue, (d) left-hand threads and is colored red, (e) left-hand threads and is colored green or black.

_____20. To clean a torch tip, you should use: (a) a reamer, (b) a twist drill, (c) a file, (d) a pipe cleaner, (e) a wire brush.

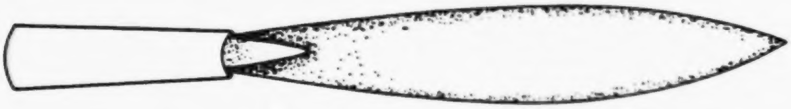
_____21. Flashback occurs when: (a) the flame goes out, (b) the flame goes inside the torch, (c) there are hose leaks, (d) there is too much gas pressure, (e) both a and d.

_____22. Backfire occurs when: (a) the flame goes out, (b) the flame goes inside the torch, (c) the oxygen is closed first, (d) there is too much gas pressure, (e) both b and d.

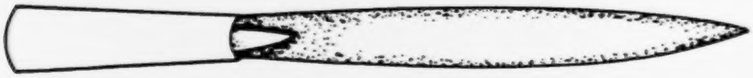
_____23. The working pressure gauge on an oxygen regulator goes from: (a) 0 to 15 psi, (b) 0 to 30 psi, (c) 0 to 150 psi, (d) 0 to 400 psi, (e) 0 to 3000 psi.

_____24. The working pressure gauge on an acetylene regulator goes from: (a) 0 to 15 psi, (b) 0 to 30 psi, (c) 0 to 150 psi, (d) 0 to 400 psi, (e) 0 to 3000 psi.

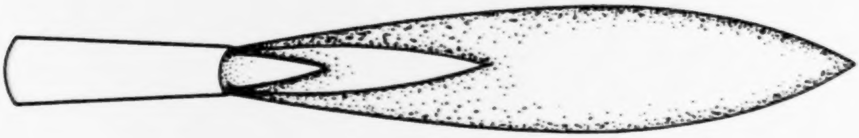
_____25. The flame shown in the illustration below is a (an): (a) carburizing flame, (b) acetylene only flame, (c) neutral flame, (d) oxidizing flame, (e) oxygen only flame.



____26. The flame shown in the illustration below is a (an): (a) carburizing flame, (b) acetylene only flame, (c) neutral flame, (d) oxidizing flame, (e) oxygen only flame.

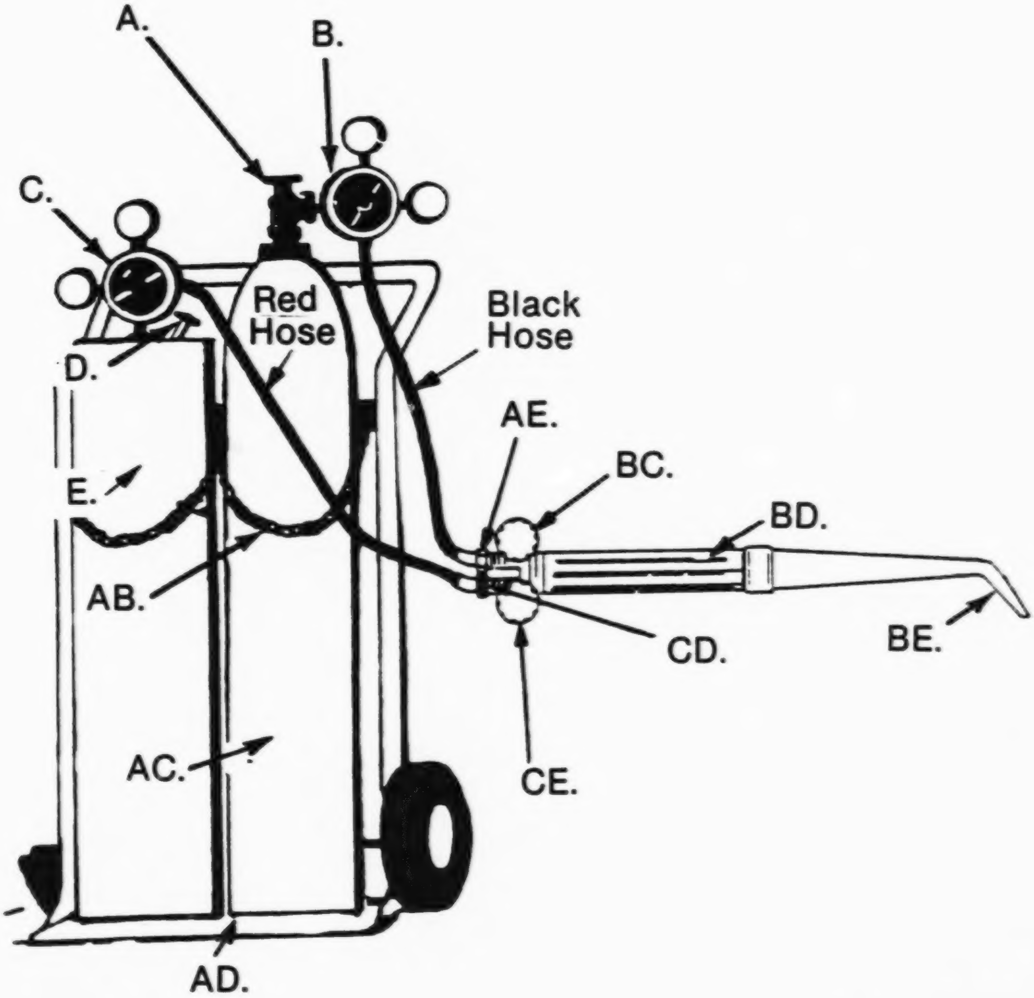


____27. The flame shown in the illustration below is a (an): (a) carburizing flame, (b) acetylene only flame, (c) neutral flame, (d) oxidizing flame, (e) oxygen only flame.



III. Label the diagram of an oxyacetylene welding unit by using the correct term from the list below.

_____28. Oxygen cylinder
_____29. Acetylene cylinder
_____30. Oxygen regulator
_____31. Acetylene regulator
_____32. Oxygen cylinder valve
_____33. Acetylene cylinder valve
_____34. Oxygen fitting
_____35. Oxygen torch valve
_____36. Acetylene fitting
_____37. Acetylene torch valve
_____38. Torch body
_____39. Welding tip



(NOTE: Successful completion of this portion of the unit test with a minimum score of ___ is necessary for the student to receive evaluations on competencies F11 and F12.)

PART II—SAFETY

I. Mark a T on the test or answer sheet if the statement is true and an F if the statement is false.

_____40. In storing or shipping gas cylinders the protective caps should be in place at all times.

_____41. You should never remove a protective cap from a gas cylinder until it is securely in position on the welding cart.

_____42. Gas cylinders should be moved by tilting them a little and rolling them on edge.

_____43. You should use a wrench to open gas cylinder valves.

_____44. You should never use oil or grease on any part of oxyacteylene equipment.

_____45. You should never substitute oxygen for compressed air.

_____46. A special flint lighter or "striker" is the only safe method of lighting an oxyacetylene torch.

_____47. Dust can explode.

_____48. You should be sure there is good ventilation when working on brass, bronze or galvanized materials because they may give off poisonous gases.

_____49. You should wear cuffless, clean clothes with the collars and sleeves buttoned when using oxyacetylene equipment.

_____50. A gas cylinder can become a deadly rocket if the valve is knocked off by accident.

_____51. You should stand in front of the oxygen regulator when the valve is opened.

_____52. The acetylene cylinder should be opened 1/4 to 1/2 turn.

_____53. You should never use acetylene at pressures above 30 psi.

_____54. You should never use cutting or welding torches where there are sparks or an open flame.

(Successful completion of this portion of the unit test is the evaluation for Competency F10, "Identify oxyacetylene welding safety procedures." Of the 15 questions, a score of _____ = 3, _____ = 2, _____ = 1, _____ or below = student should retake this portion of the unit test. A minimum score of ____ is also necessary for the student to receive an evaluation on Competency F13 "Use protective clothing and equipment.")

UNIT IV: OXYACETYLENE WELDING AND CUTTING

ANSWERS TO UNIT IV TEST

PART I.

1. AD
2. D
3. BC
4. AB
5. E
6. B
7. BE
8. AE
9. AC
10. BD

11. D
12. C
13. C
14. B
15. C
16. A
17. E
18. A
19. D
20. A
21. B
22. A
23. C
24. B

25. C
26. D
27. A

28. AC
29. E
30. B
31. C
32. A
33. D
34. AE
35. BC
36. CD
37. CE
38. BD
39. BE

PART II.

40. T
41. T
42. T
43. F
44. T
45. T
46. T
47. T
48. T
49. T
50. T
51. F
52. T
53. F
54. T

MODULE: WELDING

UNIT V: OXYACETYLENE WELDING AND CUTTING

UNIT OBJECTIVE

Upon completion of this unit the student should be able to prepare metal for oxyacetylene welding and cutting, and perform oxyacetylene welding and cutting. Mastery will be evidenced through demonstration and by achieving a score of _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Identify conditions controled by welder (Competency F11, Part I of Unit V test.)

II. Identify auto body weld joints (Competency F11, Part I of Unit V test.)

III. Demonstrate the ability to:

   a. Construct a corner weld without a filler rod (Competency F11, Job Sheet #1)

   b. Lay beads on light-gauge metal without filler rod (Competency F11, Job Sheet #2)

   c. Lay beads on light-gauge metal with filler rod (Competency F11, Job Sheet #3)

   d. Weld butt joints with filler rod (Competency F11, Job Sheet #4)

   e. Perform oxyacetylene weld destructive test

Lesson 2:

I. Identify oxyacetylene cutting equipment and procedures. (Competency F12, Part II of Unit V test)

II. Demonstrate the ability to:

   a. Set up and operate equipment for oxyacetylene cutting (Competency F12, Job Sheet #1)

   b. Make 90-degree cuts on 1/8" mild-steel plate and restart a cut (Competency F12, Job Sheet #2)

   c. Make a flame-beveled cut on 1/8" mild-steel plate and cut a hole in 1/8" mild-steel plate (Competency F12, Job Sheet #3)

MODULE: WELDING

UNIT V: OXYACETYLENE WELDING AND CUTTING

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

  1. Lesson 1: Metal Preparation and Welding

    a. Information outline

    b. Transparency masters

    TM#1: Oxyacetylene welding process
    TM#2: Running puddles

    c. Job sheets

    JS#1: Construct an oxyacetylene corner weld without filler rod
    JS#2: Lay beads on light-gauge metal without filler rod
    JS#3: Lay beads on light-gauge metal with filler rod
    JS#4: Weld a butt joint with filler rod
    JS#5: Perform oxyacetylene weld destructive test

  2. Lesson 2: Torch Cutting

    a. Information outline

    b. Transparency masters

    TM#1: Parts of a torch body and cutting attachment
    TM#2: Torch tips
    TM#3: Flame adjustment
    TM#4: Oxyacetylene torch

    c. Job sheets

    JS#1: Light and adjust torch
    JS#2: Cut mild steel at a 90-degree angle, stop, and restart a cut
    JS#3: Make a flame-beveled cut on 1/8-inch mild-steel plate and cut a hole in 1/8-inch mild-steel plate

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Any of the job sheets can be used to evaluate competency F12. Only one cut need be made.

REFERENCES USED IN WRITING THIS UNIT

1. Crouse, William H. *Automotive Mechanics.* Eighth edition. McGraw-Hill. St. Louis, MO. 1980.

2. Czapskie, George S., et. al. *Auto Body Repair.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1977.

3. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL. 1984.

4. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

5. Walters, Terry, and Walker, Susan. *Automotive Body Repairer.* Curriculum & Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education. Stillwater, OK. 1986.

MODULE: WELDING

UNIT V: OXYACETYLENE WELDING AND CUTTING

LESSON ONE: METAL PREPARATION AND WELDING

I. **Conditions controlled by welder**

- A. Preparation of metal
  - 1. Surface preparation
    - a. Remove paint with paint remover or abrasive.
    - b. Remove rust with rust remover, wire brush, or abrasive.
- B. Flame distance -- distance of the end of the flame from the work.
  - 1. Actual distance
    - a. Controls temperature and the spread of heat
    - b. Controls penetration
    - c. Controls welding light to heavy metal
  - 2. Procedure for welding sheet metal
    - a. Raise the temperature of the puddle to the melting point as quickly as possible.
    - b. Prevent the spread of heat into the surrounding metal as much as possible.
    - c. Hold the inner cone away from the puddle just slightly less than its length.
- B. Flame angle -- angle of flame to the line of the seam.
  - 1. Angle of flame
    - a. Surface
    - b. Line of the seam
    - c. Penetration

      (Note: Increase penetration by increasing angle or decrease penetration by decreasing angle.)
  - 2. Desirable procedure on welds

        a. Pointing the flame directly down the seam line on a butt weld

        (Note: Avoid unequal expansion and separate the edges even though they are tack-welded together.)

        b. Hold flame turned slightly away from the edge and hold filler rod so that it acts as shield for the exposed edge on lap welds.

        c. Weld light metal to heavy metal by holding flame toward the heavy piece.

C. Rate of travel

   1. Width of the puddle

      a. Narrow -- moving torch too fast

      b. Holes -- holding the torch in one spot too long

   2. Degree of the penetration depth

D. Weaving the flame -- side motion of the torch

   1. Heat over a wider path and slow the forward travel.

      a. Deeper penetration

      b. More time to add filler metal

   2. Welder can hold steadier using a weaving motion than moving straight forward in welding

E. Filler rod position -- position of the filler rod end in relation to the puddle and flame.

   1. Rod at an angle to the surface of approximately 45 degrees and in line with the seam

   2. Use rod to shield or prevent melting away of the exposed edge of a lap weld.

II. Auto body weld joints

A. Butt welding

   1. Alignment of the edges

      a. Spaced -- Space between the edges should be about the same as the thickness of the metal.

      b. Flush -- Edges of the surface to be welded.

      (Note: This avoids uneven heat distortion)

   2. Tack welding

- a. The torch manipulation should be nearly vertical because this results in the least heat distortion.
- b. The size of the tack should be as small as possible.
- c. Control heat distortion by using a hammer and dolly block.

  (Note: Never use on a tack until the metal has cooled.)

3. Welding the seam
   - a. Weld only a short distance and stay.
   - b. Avoid excessive heat in the panel.
   - c. Beads used on sheet metal should be made nearly flush with surface.

B. Lap weld

1. Tack
   - a. Fasten long lap welds (screws and rivets first).
   - b. Use filler rod as a shield between flame and upper piece.

C. Plug weld

1. Use small flame and almost-vertical position.
2. Rod should be kept close to the flame as hole is being melted.
3. As the hole fills, the rod should be shifted to shield the edge of the hole at any point.

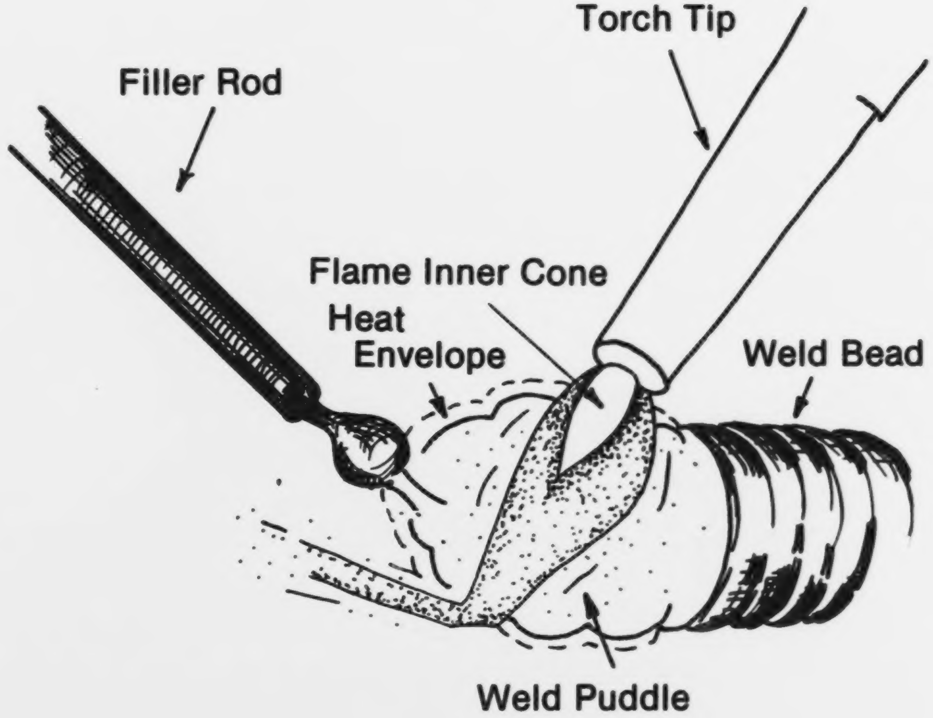
D. Corner weld

(In this weld two sections are joined at right angles to each other, edge-to-edge, such that they form an "L.")

1. Tack first.
2. Rodless (flame directly down line of seam)

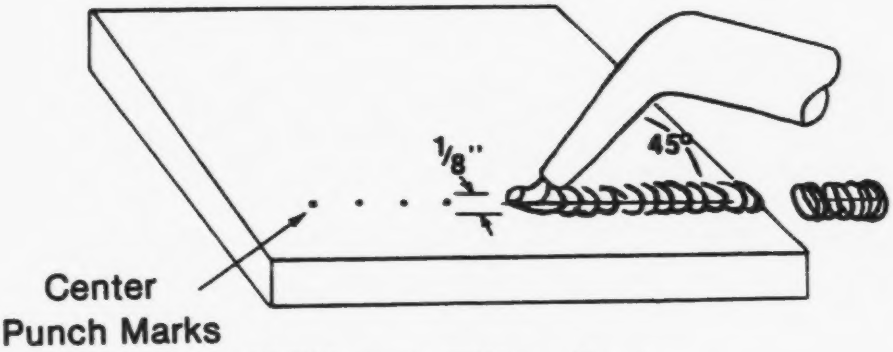
   (**CAUTION:** *Do not use oxyacetylene welding on high-strength steel.)*

Oxyacetylene Welding Process

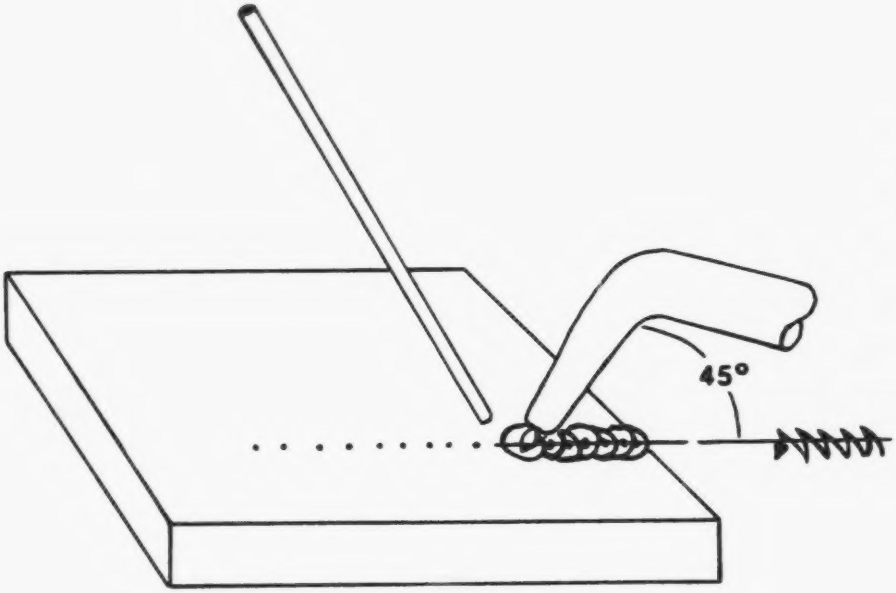

Torch Tip
Filler Rod
Flame Inner Cone
Heat Envelope
Weld Bead
Weld Puddle

TM 2

Running Puddles


1/8"
45°
Center Punch Marks

Without Filler Rod



With Filler Rod

UNIT V

JOB SHEET #1, LESSON ONE

CONSTRUCT AN OXYACETYLENE CORNER WELD WITHOUT FILLER ROD

Equipment:

Oxyacetylene welding unit
Welding tip (according to manufacturer's recommendation)
Welding rod
Gloves
Goggles
Pliers
Wire brush
Spark lighter
Fire brick
Two pieces of sheet metal 1" x 2" of metal steel

Procedure: **Evaluation:**

3 2 1 N

1. Prepare metal for welding and place metal in welding position. ___ ___ ___ ___

   (Note: Two pieces of metal are aligned at a right angle, edge-to-edge with no gap.)

2. Check welding equipment for proper operation. ___ ___ ___ ___

3. Select size of tip (according to manufacturer's recommendations) and attach to torch. ___ ___ ___ ___

4. Turn on gas cylinders slowly and adjust to working pressures (according to manufacturer's recommendations). ___ ___ ___ ___

   (**CAUTION:** *Acetylene cylinder valve open only to 1/4 to 1/2 turn and oxygen fully open.)*

5. Put on goggles and protective clothing. ___ ___ ___ ___

6. Light and adjust torch to a neutral flame. ___ ___ ___ ___

   (NOTE: Torch held in right hand should be positioned on the right side of the piece of metal and the work should progress toward the left. If you are left-handed, the procedure is just the opposite.)

Procedure:	**Evaluation:** 3	2	1	N
7. Tack weld the ends of the metal pieces together, tack welding about every three inches.	___	___	___	___
8. Form puddle at one end of the metal (torch side) and run bead down joint until weld is complete.	___	___	___	___
9. Run additional beads for multi-pass weld, as instructed by teacher.	___	___	___	___
10. Check welds for even ripple, buildup, and penetration.	___	___	___	___
11. After satisfactory completion of weld, turn off the torch and shut down welding unit.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is one of the evaluations for Competency F11 "Set up and use equipment for oxyacetylene welding.")

UNIT V

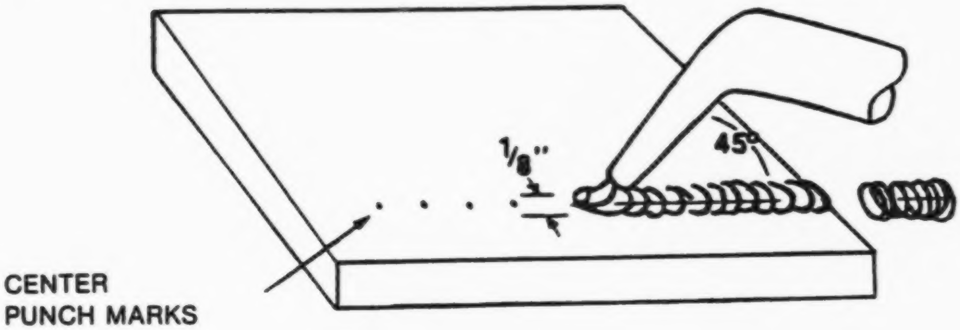
JOB SHEET #2, LESSON ONE

LAY BEADS ON LIGHT-GAUGE METAL WITHOUT FILLER ROD

Equipment:

Oxyacetylene welding unit
Welding tip recommended by manufacturer
Welding gloves
Protective clothing and eye protection
Pliers
Wire brush
Flint lighter
Firebricks
Mild steel plate
Foam or multipurpose dry-chemical fire extinguisher
Tip cleaners

FIG. 1-1



WITHOUT FILLER ROD

Procedure:	Evaluation:			
	3	2	1	N
1. Put on protective clothing and eye protection and prepare metal for welding.	___	___	___	___
2. Place metal on firebricks in welding position.	___	___	___	___
3. Turn on oxyacetylene unit and set working pressure according to manufacturer's recommendations.	___	___	___	___
4. Light torch and adjust to a neutral flame.	___	___	___	___
5. Place inner cone about 1/16 inch to 1/8 inch from metal and hold torch 30 to 45 degrees from vertical in direction of travel.	___	___	___	___
6. Do not begin travel until a molten puddle forms. Then slowly move torch forward in a circular or back-and-forth motion, allowing metal to melt.	___	___	___	___
7. Repeat process for multiple-pass weld, as instructed.	___	___	___	___
8. Inspect bead for proper formation.	___	___	___	___
9. If weld is satisfactory, turn off torch and shut down welding equipment.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is one of the evaluations for Competency F11 "Set up and use equipment for oxyacetylene welding.")

UNIT V

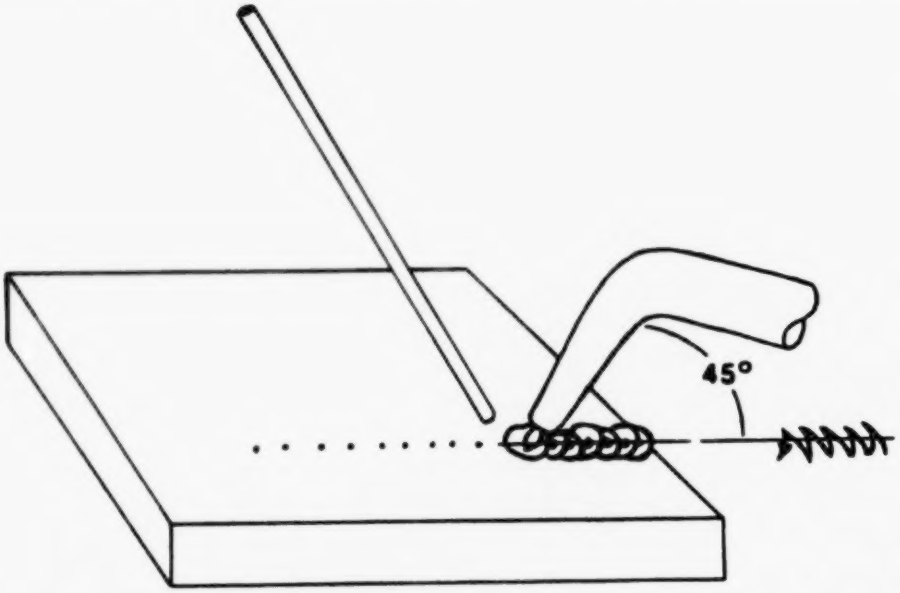
JOB SHEET #3, LESSON ONE

LAY BEADS ON LIGHT-GAUGE METAL WITH FILLER ROD

Equipment:

Oxyacetylene welding unit
Welding tip recommended by manufacturer
Welding gloves
Protective clothing and eye protection
Pliers
Wire brush
Flint lighter
Firebricks
Light-gauge mild steel
Filler rod mild steel recommended by manufacturer
Foam or multipurpose dry-chemical fire extinguisher
Tip cleaners

FIG. 1-2



WITH FILLER ROD

Procedure:	**Evaluation:** 3	2	1	N
1. Put on protective clothing and eye protection and prepare metal for welding.	___	___	___	___
2. Place metal on firebricks in welding position.	___	___	___	___
3. Turn on oxyacetylene unit and set working pressure according to manufacturer's recommendation.	___	___	___	___
4. Light torch and adjust to a neutral flame.	___	___	___	___
5. Hold torch 30 to 45 degrees from vertical in direction of travel.	___	___	___	___
6. Place inner cone about 1/16 inch to 1/8 inch from surface of puddle, establish molten puddle.	___	___	___	___
7. Add filler rod to front edge of puddle in front of torch, and move puddle forward with torch, letting puddle form in base metal.	___	___	___	___
8. Add rod and withdraw rod to front edge of puddle as you move puddle forward, keeping puddle the same size and shape the entire length of the bead.	___	___	___	___
9. Examine bead for proper formation.	___	___	___	___
10. If weld is satisfactory, turn off torch and shut down welding equipment.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is one of the evaluations for Competency F11 "Set up and use equipment for oxyacetylene welding.")

UNIT V

JOB SHEET #4, LESSON ONE

WELD A BUTT JOINT WITH FILLER ROD

Equipment:

Oxyacetylene welding unit
Welding tip recommended by manufacturer
Welding gloves
Protective clothing and eye protection
Pliers
Wire brush
Flint lighter
Firebricks
Two pieces of mild steel plate
Filler rod mild steel recommended by manufacturer
Foam or multipurpose dry-chemical fire extinguisher
Tip cleaners

Procedure:

Evaluation:
3 2 1 N

1. Put on protective clothing and eye protection and prepare metal for welding. ___ ___ ___ ___
2. Place metal on firebricks in welding position, 1/16- to 1/8-inch apart. ___ ___ ___ ___
3. Turn on oxyacetylene unit and set working pressure according to manufacturer's recommendation. ___ ___ ___ ___
4. Light torch and adjust to a neutral flame. ___ ___ ___ ___
5. Tack-weld together every 1 to 2 inches. ___ ___ ___ ___
6. Hold torch 30 degrees to 45 degrees from vertical. ___ ___ ___ ___
7. Place inner cone about 1/16 inch to 1/8 inch from surface of puddle. Establish molten puddle before beginning travel. ___ ___ ___ ___
8. Add filler rod to front edge of puddle in front of torch and move the puddle forward with torch and allow puddle to form in base metal. ___ ___ ___ ___
9. Add rod and withdraw rod to front edge of puddle as you move puddle forward. Keep puddle the same size and shape for the entire length of the bead. ___ ___ ___ ___

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
10. Examine bead for proper formation.	___	___	___	___
11. If weld is satisfactory, turn off torch and shut down welding equipment.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is one of the evaluations for Competency F11 "Set up and use equipment for oxyacetylene welding.")

UNIT V

JOB SHEET #5, LESSON ONE

PERFORM OXYACETYLENE WELD DESTRUCTIVE TEST

Equipment:

Oxyacetylene welding unit
Welding tip recommended by manufacturer
Welding gloves
Protective clothing and eye protection
Pliers
Wire brush
Flint lighter
Firebricks
Two pieces of mild-steel plate
Filler rod mild steel recommended by manufacturer
Foam or multipurpose dry-chemical fire extinguisher
Tip cleaners
Vice
Hammer of appropriate size

Procedure:	**Evaluation:** 3	2	1	N
1. Weld corner weld or butt weld by performing appropriate job sheet.	___	___	___	___
2. Place welded workpiece in vice and clamp in position.	___	___	___	___
3. Select hammer of appropriate size and hammer on workpiece in such a way that the workpiece bends against the face of the weld.	___	___	___	___
4. Continue hammering until a significant bend in the welded piece has been achieved (Consult instructor).	___	___	___	___
5. Check weld. If weld has bent without holes forming, the weld tearing or the weld breaking, then it passes the destructive test.	___	___	___	___

Average of above evaluations.*

(*This average would be the evaluation for an area beyond the specified competencies.)

MODULE: WELDING

UNIT V: OXYACETYLENE WELDING AND CUTTING

LESSON TWO: TORCH CUTTING

I. **Oxyacetylene cutting equipment and procedures**

- A. Parts of a cutting torch and tip
  - 1. Cutting torch
    - a. Oxygen fitting
    - b. Acetylene fitting
    - c. Oxygen torch valve
    - d. Acetylene torch valve
    - e. Torch body
    - f. Oxygen preheat valve
    - g. Oxygen cutting lever
    - h. Tip nut
    - i. Cutting tip
  - 2. Cutting tip
    - a. Cutting oxygen hole -- supplies the cutting oxygen stream (center hole).
    - b. Preheat holes -- heats the metal to required temperature (outer holes).
- B. Uses
  - 1. Cut apart mangled sheet-metal assemblies
  - 2. Cut off rusty bolts, welds and rivets in the frame
  - 3. Remove panel sections that are to be replaced

    *(**Caution:** Not recommended for high-strength steel)*
- C. Disadvantages
  - 1. High heat dispersion

2. If used on high-strength steel, allow at least two inches of overlap for heat dispersion.

   (Note: The oxyacetylene torch may be used on mild steel but a metal saw is recommended on all other steels.)

D. Backfire -- flame burns back into tip and causes loud snap or pop.

   1. Insufficient acetylene or oxygen pressure
   2. Loose cutting tip
   3. Overheating of cutting
   4. Dirty tip
   5. Damaged O-ring in torch body

   (**CAUTION:** *If these problems exist, correct immediately.)*

E. Flashback -- fire inside torch.

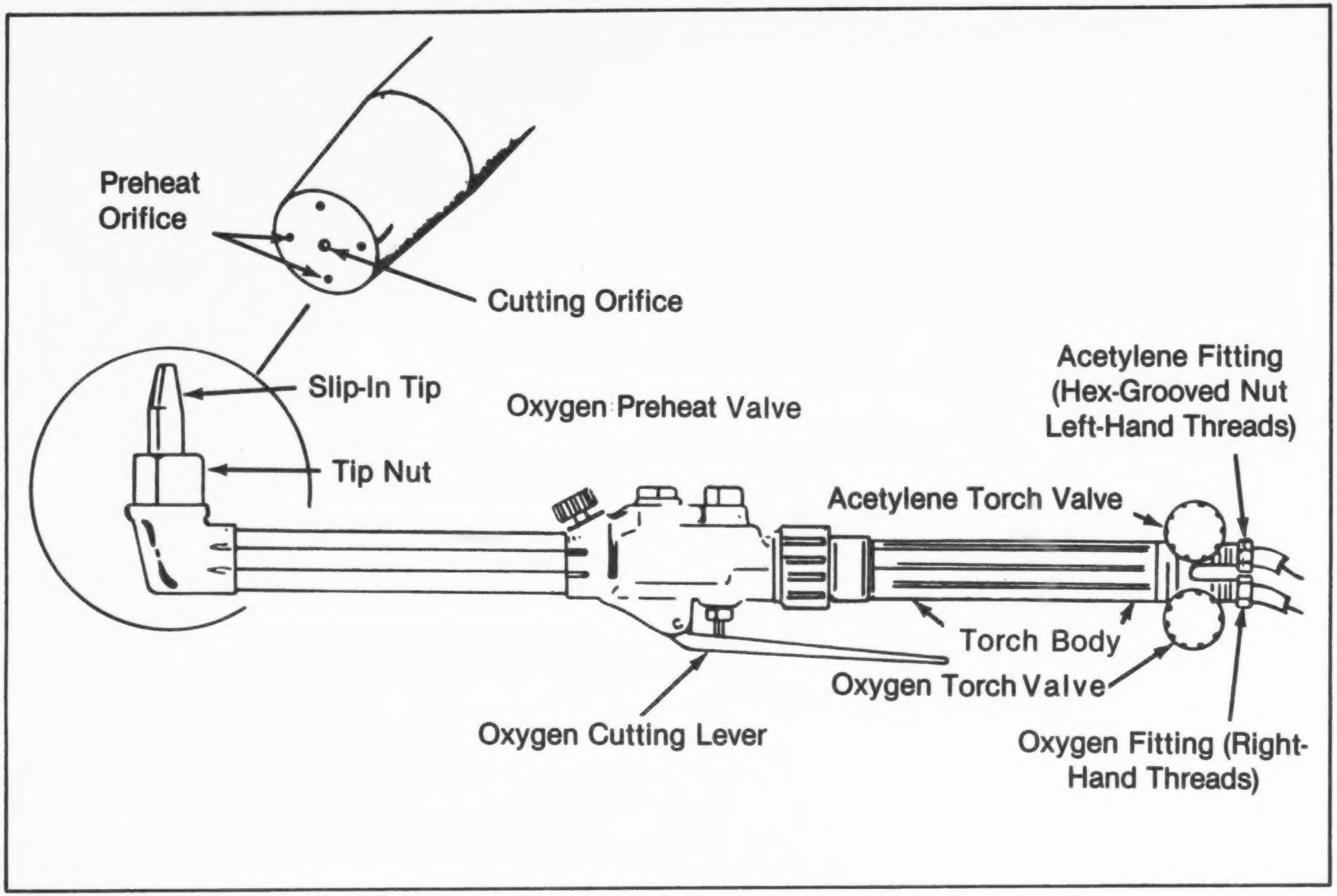
   1. Disappearance of flame followed by:
      a. Squealing or hissing noise inside torch
      b. Sparks coming from the torch
      c. Smoke coming from the torch
   2. Procedure to follow in case of flashback
      a. Close oxygen preheat valve.
      b. Close oxygen torch valve.
      c. Close acetylene torch valve.
      d. Release oxygen regulator screw.
      e. Release acetylene regulator screw.
      f. Examine acetylene unit.
      g. Reset regulator pressure.
      h. Light torch.

      (**CAUTION:** *If heavy smoke comes out of the torch tip and the torch body becomes hot, the flashback has probably traveled past the mixing chamber into the hose. In this case, shut off the oxygen cylinder valve and the acetylene cylinder valve; notify your instructor.)*

F. Speed of movement

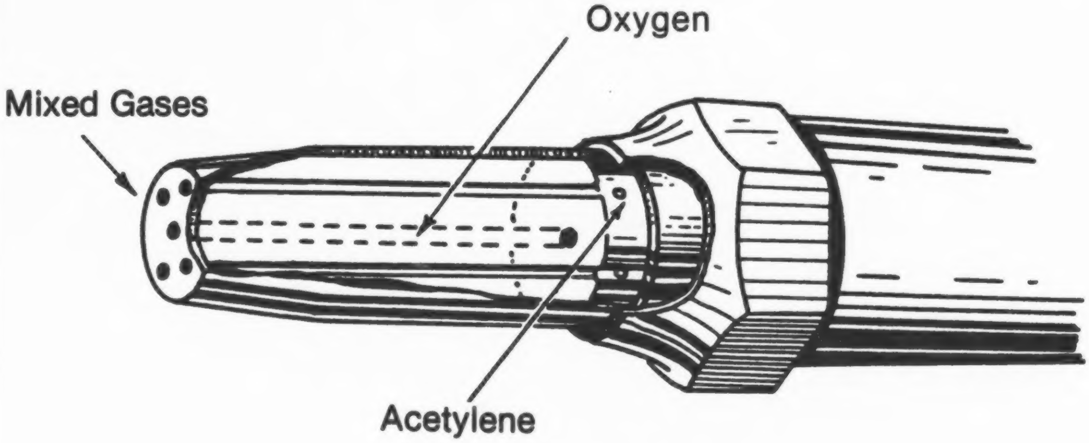
1. Slow - cut will fuse
2. Fast - cut will last

Parts of a Torch Body and Cutting Attachment

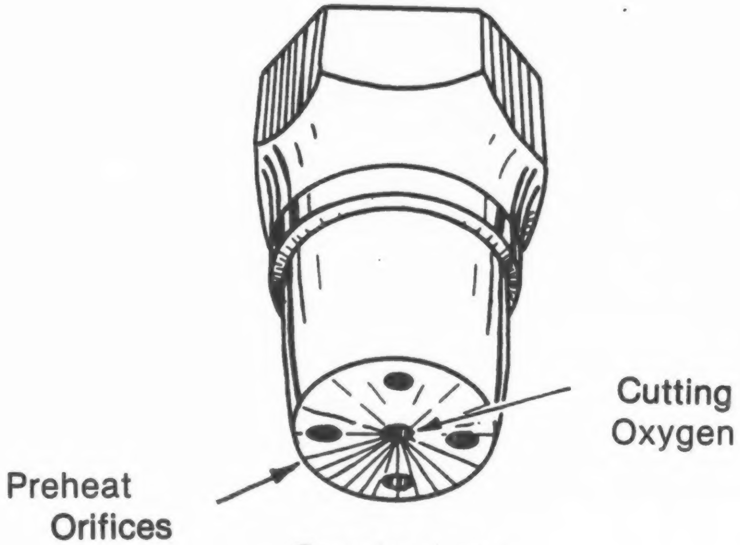

Preheat Orifice
Cutting Orifice
Slip-In Tip
Tip Nut
Oxygen Preheat Valve
Acetylene Fitting (Hex-Grooved Nut Left-Hand Threads)
Acetylene Torch Valve
Torch Body
Oxygen Torch Valve
Oxygen Cutting Lever
Oxygen Fitting (Right-Hand Threads)

TM 2

Torch Tips


Oxygen
Mixed Gases
Acetylene

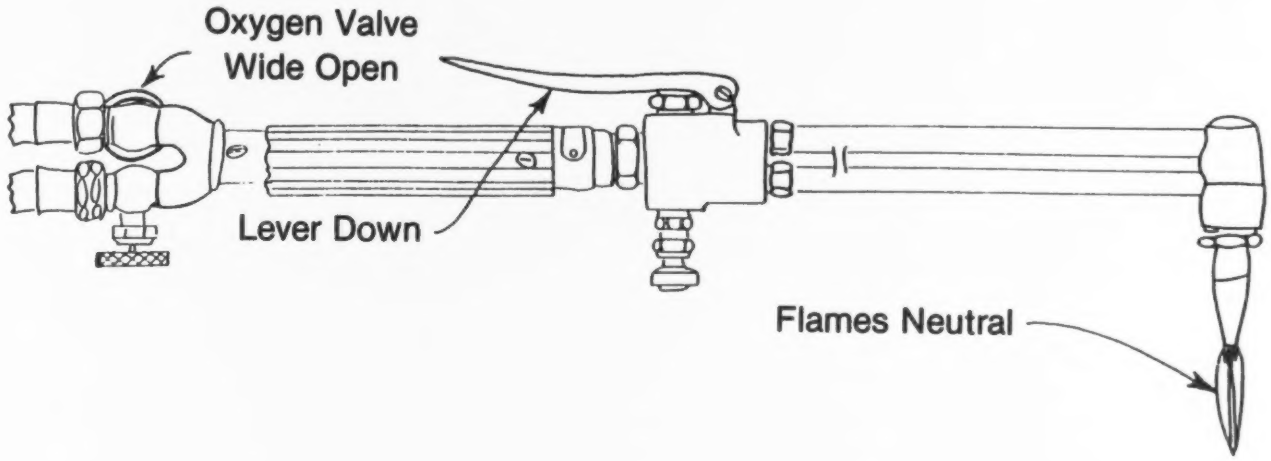
Welding Tip


Cutting
Oxygen
Preheat
Orifices

Cutting Tip

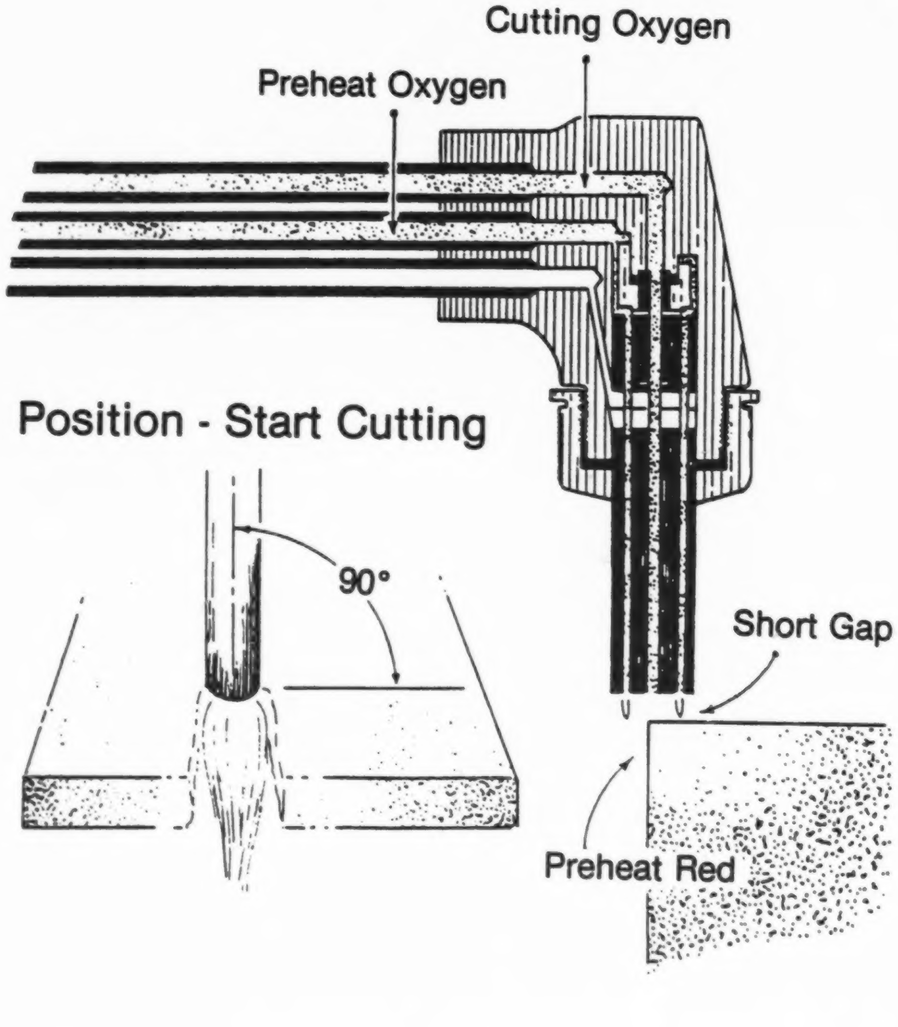
Flame Adjustment

1. Open blowpipe oxygen valve as far as you can. **Leave it wide open!**
2. Push down cutting oxygen lever and adjust flames with needle valve on cutting attachment.


Oxygen Valve Wide Open
Lever Down
Flames Neutral

TM 4

Oxyacetylene Torch


Cutting Oxygen
Preheat Oxygen
Position - Start Cutting
90°
Short Gap
Preheat Red

UNIT V

JOB SHEET #1, LESSON TWO

LIGHT AND ADJUST TORCH

Equipment:

Oxyacetylene welding unit
Cutting torch and proper tip
Welding gloves
Protective clothing and eye protection
Pliers
Wire brush
Flint lighter
Firebricks
Foam or multipurpose dry-chemical fire extinguisher
Tip cleaners

Procedure:	**Evaluation:** 3	2	1	N
1. Fasten cutting tip to torch body and adjust gauges to proper pressure.	___	___	___	___
2. Completely open oxy-valve on torch body, then open acetylene valve 1/4 turn.	___	___	___	___
3. After making sure torch tip is clear of all objects, use striker to ignite torch.	___	___	___	___
4. Open oxygen valve on cutting tip and adjust to desired cutting flame for thickness of metal.	___	___	___	___
5. To turn off flame, close acetylene valve first, then turn off oxygen valve on torch.	___	___	___	___
6. Turn off oxygen valve on torch body and then close oxygen cylinder valve.	___	___	___	___
7. Open acetylene valve on torch to bleed hose, then open oxygen valve on torch to bleed hose.	___	___	___	___
8. Rewind hose and replace on hangar.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average will be transferred to one of the following job sheets.)

UNIT V

JOB SHEET #2, LESSON TWO

CUT MILD STEEL AT A 90-DEGREE ANGLE, STOP, AND RESTART THE CUT

Equipment:

Oxyacetylene cutting outfit with tip assembly
Mild steel plate
Soapstone and straightedge
Pliers
Protective clothing and eye protection
Flint lighter
Welding or cutting table
Can of water
Foam or multipurpose dry-chemical fire extinguisher
Tip cleaners

Procedure:	Evaluation:			
	3	2	1	N
1. Put on protective clothing and eye protection and mark four parallel lines two inches apart on plate to be cut.	___	___	___	___
2. Check torch for proper operation by performing Job Sheet #1, this lesson.	___	___	___	___
3. Put on proper cutting tip then completely open oxy-valve on torch body, then open acetylene valve 1/4 turn.	___	___	___	___
4. After making sure torch tip is clear of all objects, use striker to ignite torch.	___	___	___	___
5. Open oxygen valve on cutting tip and adjust to desired cutting flame for thickness of metal.	___	___	___	___
6. Using both hands, hold preheat flame with tip of inner cone 1/16 inch to 1/8 inch above top of plate at right edge until red spot appears.	___	___	___	___
7. Depress oxygen cutting lever and move from right to left across the plate. (Left-handed operators move from left to right.)	___	___	___	___

Procedure:

Evaluation:
3 2 1 N

8. Hold tip at correct angle to work for thickness of metal, while cutting with inner cone approximately 1/16 inch above work. ___ ___ ___ ___

   (NOTE: The thicker the metal, the closer to a right angle the tip should be held.)

9. Make 90-degree cuts until you have developed the proper procedure. ___ ___ ___ ___

10. Cool metal by placing in can of water with the aid of pliers. ___ ___ ___ ___

11. Restart a cut by releasing oxygen cutting lever, preheating the edge where the cutting was stopped, and then depressing the oxygen lever slowly. ___ ___ ___ ___

12. Have instructor check work, shut off cutting equipment properly. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is one of the evaluations for Competency F12 "Set up and use equipment for oxyacetylene cutting.")

UNIT V

JOB SHEET #3: LESSON TWO

MAKE A FLAME-BEVELED CUT ON 1/8 INCH MILD STEEL PLATE AND CUT A HOLE IN 1/8th INCH MILD STEEL PLATE

Equipment:

Oxyacetylene welding unit
Cutting tips (according to manufacturer's recommendation)
Cutting torch
Gloves
Pliers
Goggles
Wire brush
Strike lighter
Fire brick
Scrap 1/8-inch mild-steel plate
Soapstone

Procedure:

Evaluation:
3 2 1 N

1. Put on goggles and protective clothing and check welding equipment for operational use. ____ ____ ____ ____

2. Select size of cutting tip (according to manufacturer's recommendations) and attach to cutting torch. ____ ____ ____ ____

3. Clean metal and mark cutting line with soapstone and mark hole to be cut. ____ ____ ____ ____

4. Turn on gas cylinders slowly and adjust to working pressures according to manufacturer's recommendations. Turn on acetylene valve first, opening only 1/4 to 1/2 turn and then open oxygen fully. ____ ____ ____ ____

5. Open the acetylene valve slightly on torch and light it with a striker. ____ ____ ____ ____

   (NOTE: Open acetylene valve until the flame burns brightly.)

6. Open oxygen valve on the cutting torch until it gives a neutral flame on the preheat flames. ____ ____ ____ ____

   (NOTE: When the lever on the cutting attachment is depressed, the full flow of oxygen comes out of the center orifice. Be careful to note where hot metal will lane.)

Procedure:

Evaluation:
3 2 1 N

7. Torch tip is held at angle to be beveled, usually 30 to 45 degree angle to the metal and the pale blue core of the preheat flame is kept about 1/16 of an inch away. ___ ___ ___ ___

   (Note: Maneuver torch with both hands.)

8. Spot under the preheat flame until metal begins to melt. Then depress oxygen valve and begin cutting. ___ ___ ___ ___

9. Continue cut to end. ___ ___ ___ ___

10. Preheat area where hole is to be cut. ___ ___ ___ ___

    (Note: If hole is large, it will have to be cut out following a line around the circumference of the hole. Small holes can be blown straight through.)

11. When metal begins to melt, cut hole according to size instructed. ___ ___ ___ ___

12. Check cuts with instructor for approval and grading, turn off torch and shut down welding unit. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is one of the evaluations for Competency F12 "Set up and use equipment for oxyacetylene cutting.")

MODULE: WELDING

UNIT V: OXYACETYLENE WELDING AND CUTTING

UNIT V TEST

PART I–OXYACETYLENE WELDING

I. Mark a T on the test or answer sheet if the statement is true and an F if the statement is false.

_____1. In preparing metal for oxyacetylene welding, you should remove the paint with paint remover and abrasive.

_____2. In preparing metal for oxyacetylene welding, you should remove rust with rust remover, a wire brush and abrasive.

_____3. The flame distance controlled by the welder is the distance from the tip of the torch to the end of the flame.

_____4. In welding sheet metal, you should raise the temperature of the puddle to the melting point at a slow and even rate.

_____5. In welding sheet metal, you should hold the inner cone away from the puddle just slightly less than its length.

_____6. The flame angle is the angle of the flame to the line of the seam.

_____7. Increasing the flame angle increases the penetration of the weld.

_____8. In welding light metal to a heavier metal, the flame should be held toward the light metal.

_____9. If the bead is narrow it means you are moving the torch too fast.

_____10. If holes develop in the metal it means you have too much filler rod.

_____11. Weaving the flame allows deeper penetration and more time to add filler metal.

_____12. The filler rod should be held at a 90-degree angle and in line with the seam.

_____13. On a lap weld, the filler rod should be used as a shield to prevent melting away the exposed edge of the lap weld.

_____14. On a spaced butt weld for oxyacetylene welding, the space between the two edges should be about the same as the thickness of the filler rod.

_____15. In tack welding, the torch should be held nearly vertical to reduce heat distortion.

_____16. A tack weld should be as small as possible.

_____17. In oxyacetylene welding you can weld continuously on a long seam of high-strength steel.

_____18. A weaving motion helps the welder because it is easier to hold a weaving motion steady that a straight motion.

_____19. To make an oxyacetylene plug weld, you should use a large flame and hold the torch nearly vertical.

_____20. In an oxyacetylene plug weld, you should hold the rod close to the flame as the hole is being melted.

(NOTE: Completion of this portion of the unit test with a minimum score of _____ is necessary for the student to receive evaluations on Competency F11.)

PART II--OXYACETYLENE CUTTING

I. Arrange the following steps of procedure in case of flashback in order by marking the letter(s) of the steps in the correct order on questions 32-39 on the answer sheet.

_____21.

_____22.

_____23.

_____24.

_____25.

_____26.

_____27.

_____28.

A. Close acetylene torch valve

B. Examine acetylene unit

C. Light torch

D. Close oxygen torch valve

E. Release acetylene regulator screw

AB. Close oxygen preheat valve

AC. Release oxygen regulator screw

AD. Reset regulator pressure

II. Select the best answer from the five choices listed.

_____29. The oxyacetylene cutting torch can be used to remove panel sections, but not if you are going to cut through: (a) mild steel, (b) high-strength steel, (c) unibody panels, (d) panels that will be completely replaced, (e) b or c.

_____30. Backfire can be caused by insufficient oxygen or acetylene pressure, or by: (a) a loose cutting tip, (b) overheating of cutting, (c) dirty tip, (d) damaged O-ring in torch body, (e) all of the above.

_____31. If heavy smoke comes out of the torch and the torch body gets hot, you should: (a) shut off oxygen and acetylene torch valves, (b) shut off oxygen and acetylene cylinder valves, (c) notify instructor, (d) b, then c, (e) a, then c.

_____32. You should work as swiftly as possible in using a cutting torch to avoid: (a) arm fatigue, (b) the cut fusing back together, (c) heat distortion, (d) b and c, (e) a, b and c.

_____33. The oxygen preheat holes are used to: (a) warm up the torch tip, (b) raise the metal to the melting point, (c) prevent heat distortion, (d) cut the metal, (e) prevent backfire.

_____34. The oxygen cutting hole is used to: (a) warm up the torch tip, (b) raise the metal to the melting point, (c) prevent heat distortion, (d) cut the metal, (e) prevent backfire.

(NOTE: Completion of this portion of the unit test with a minimum score of ____ is necessary for the student to receive evaluations on Competency F12.)

ANSWERS TO UNIT V TEST

PART I.

1. T
2. T
3. F
4. F
5. T
6. T
7. T
8. F
9. T
10. F
11. T
12. F
13. T
14. F
15. T
16. T
17. F
18. T
19. F
20. T

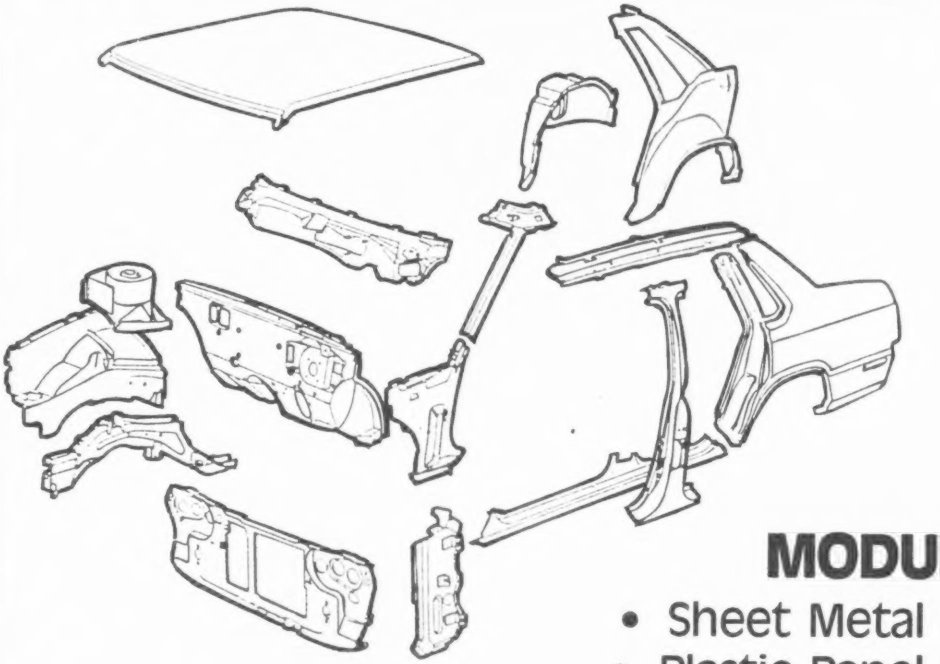
PART II.

21. AB
22. D
23. A
24. AC
25. E
26. B
27. AD
28. C

29. e
30. e
31. d
32. d
33. b
34. d

Auto Body Repair Curriculum Guide

INSTRUCTOR'S GUIDE



MODULE 3:

- Sheet Metal Repair
- Plastic Panel Repair
- Fiberglass Panel Repair
- Body Panel Replacement
- Bumpers
- Safety

Panel Repairs

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AUTO BODY CURRICULUM
Instructor's guide

MODULE 3:
PANEL REPAIRS

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Alan Polley, and Don Robert**

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Unit VII: Corrosion protection 201

Auto Body

Panel Repairs

Cross-Reference Table of Instructional Materials

Competency	Unit	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
G 1	I	1-I, 1-III	1-3			1	1-30	
G 2	I	2-I--2-II				1	1-30	
G 3	I	2-I--2-II	1-2			2-5	1-30	
G 4	I	2-I--2-II	3			7	1-30	
G 5	II	1-III	2			1, 2	1-25	
G 6	II	1-IV--1-V	2			3	1-25	
G 7	II	1-VI				4	1-25	
G 8	VII	1-I--1-III				1	1-25	
G 9	I	2-I--2-II				6	1-30	
J 1	III	1-I--1-II	1			1	1-18	
J 2	III	1-I--1-II				4	1-18	
J 3	III	2-I--2-III				1-4	19-32	
J 4	III	1-I--1-II				5	1-18	
J 5	III	1-I--1-II	2			3	1-18	
J 6	III	1-I--1-II	2			2	1-18	
H 1	IV	1-I				2	1-15	
H 2	IV	1-I--1-II				2	16-35	
H 3	IV	1-I--1-II				1	16-35	
H 4	IV	1-I--1-II				4	16-35	
H 5	IV	1-I--1-II				3	16-35	
H 6	IV	1-I--1-II				4	16-35	
H 7	IV	1-I--1-II				5, 6	16-35	
I 1	V	1-I					1-15	
I 2	V	1-I			1		1-15	
I 3	V	1-I				1	1-15	
I 4	V	1-I	1-4			2	1-15	
I 5	V	1-I	1-4			3	1-15	
K 1	VI	1-I--1-III				1	1-15	
K 2	VI	1-I--1-III				1	1-15	
K 3	VI	1-I--1-III				2	1-15	
K 4	VI	1-I--1-III					1-15	K4 evaluated by
	IV	1-I--1-II				4	16-35	JS #4, Unit IV

MODULE: PANEL REPAIRS

UNIT I: SHEET METAL REPAIR AND ROUGHOUT

UNIT OBJECTIVE

After completion of this unit, the student should be able to analyze damage to metal panels, select proper repair techniques, and roughout panels to proper dimension and alignment. Mastery will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Lesson 1:

I. Match the terms with their definitions (Competencies G1-G4, Unit I test)

II. Identify basic properties of metal and guidelines for repair (Competencies G1-G4, Unit I test)

III. Identify types of damage (Competencies G1-G4, Unit I test)

IV. Demonstrate the ability to analyze damage (Competency G1, Job Sheet #1)

Lesson 2:

I. Match terms with their definitions (Competencies G1-G4, Unit I test)

II. Identify roughout techniques (Competencies G1-G4, Unit I test)

III. Demonstrate the ability to:

  a. Clean the exterior surface (Competency G2, Job Sheet #1)

  b. Use hammer and dolly to roughout panel (Competency G3, Job Sheet #2)

  c. Use pull rods to roughout panel (Competency G3, Job Sheet #3)

  d. Use pry bars to roughout panel (Competency G3, Job Sheet #4)

  e. Use hydraulic body jacks to roughout panel (Competency G3, Job Sheet #5)

  f. Use weld-on stud gun to repair sheet metal (Competency G9, Job Sheet #6)

  g. Shrink a panel (Competency G4, Job Sheet #7)

MODULE: PANEL REPAIRS

UNIT I: SHEET METAL

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

1. Lesson 1: Sheet Metal Repair

    a. Information outline

    b. Transparency masters

        TM#1: Effects of bending on sheet metal
        TM#2: Stretch
        TM#3: Hinge buckle

    c. Job sheets:

        JS#1: Analyze damage

2. Lesson 2: Roughout

    a. Information outline

    b. Transparency masters

        TM#1: Hammering on the dolly
        TM#2: Hammering off the dolly
        TM#3: Shrinking

    c. Job sheets:

        JS#1: Clean the exterior surface
        JS#2: Use hammer and dolly to roughout panel
        JS#3: Use pull rods to roughout panel
        JS#4: Use pry bars to roughout panel
        JS#5: Use hydraulic body jacks to roughout panel
        JS#6: Use weld-on stud gun to repair sheet metal
        JS#7: Shrink a panel

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Any of job sheets #2 through #5 may be used to evaluate competency G3 "Roughout panel." It is suggested that Job Sheet #2 and at least one of the other three job sheets be used. The results can be averaged.

REFERENCES USED IN WRITING THIS UNIT

1. Blackhawk Automotive. *New Science of Unibody Repair.* Blackhawk Automotive. Milwaukee, WI. 1984.

2. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

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7. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

8. Toboldt, Bill. *Auto Body Repairing and Repainting.* The Goodheart-Willcox Co. Inc. South Holland, IL. 1982.

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MODULE: PANEL REPAIRS

UNIT I: SHEET METAL REPAIR

LESSON ONE: BASIC METAL STRAIGHTENING

I. **Terms and definitions**

A. Direct damage -- Damage which is the direct result of the collision force at the point of impact and the immediately surrounding area. (Also known as primary damage.)

B. Direction of impact -- The direction that the metal has shifted from the impact point.

C. Ductility -- The ability of metal to be stretched without breaking.

D. Elastic limit -- The amount of bending metal can undergo and still return to its original shape.

E. Hinge buckle--Bending or pivot point from which two areas of relatively undamaged metal have moved or shifted.

F. Indirect damage -- Damage that results to panels or areas of panels which have been forced to change shape due to the pressure resulting from direct damage. (Also known as secondary damage.)

G. Malleability -- The ability of metal to be compressed without breaking.

H. Oil canning -- An area of metal in a damaged area which has been deformed but has not reached its elastic limit. Such areas result from stresses in the surrounding area of the panel and will pop in and out (like the bottom of an oil can).

I. Plasticity -- The ability of something to be forced into a new shape without breaking.

J. Roll buckle -- An area of damage where metal on each side of a pivot point is pulled together and forms a crease.

K. Roughout -- The stage in body repair where dimensions are established, damaged panels are aligned, and dents are reshaped to proper dimensions.

L. Stress relief -- Returning stretched and compressed areas of metal to their original granular structure by means of applying heat or hammer blows. The process returns the molecules of the metal to a natural state.

M. Stretch -- Swelling and thinning of metal due to bending and pulling forces. Stretch can also result from improper hammer and dolly techniques.

N. Upset -- Opposite of stretch; compressing the metal. Also known as compression.

O. Work hardening -- Change of the granular structure of metal by bending or forming; work hardening occurs in the bend and the metal becomes hardened (more resistant to changing shape).

P. Yield point -- The point at which metal will stop flowing under pressure and will break.

II. Properties of metal and guidelines for proper metal straightening

A. Metal straightening and refinishing has formed the foundation of auto body repair for years.

(NOTE: Although metal straightening will continue to be important in the future, it is expected that plastic repair will reach equal or greater importance due to the increasing use of plastic body panels.)

B. Most all collision repair will involve metal straightening and refinishing.

C. Three things must be restored to factory specifications in proper metal refinishing and repair:

1. Function

2. Appearance

3. Strength

D. Function is especially important for moveable panels, such as doors, hoods, and deck lids.

1. These panels must be restored to proper alignment

2. These panels must move freely, as intended

E. Appearance is important to all visible panels

(NOTE: Although the customer is concerned about function and strength, the customer will be unhappy if the appearance is less than perfect.)

F. The strength of each repaired panel must be relatively equal to the strength of the pre-damaged panel.

1. Structural panels must be restored to EXACTLY their original strength and integrity.

   (NOTE: In the case of modern unibody designs it is NOT acceptable to restore a structural panel to GREATER strength than its pre-damaged condition. This is because many unibody structural panels are designed to yield at particular pressures, thereby controlling the effects of the collision. See Module 7 on unibody construction.)

2. Cosmetic panels must be restored to APPROXIMATELY their original strength, and will be if proper repair and refinishing methods are followed.

G. Sequence of proper metal straightening and repair

1. Analyze damage.

   a. Note extent of damage.

  - b. Note type of metal, using shop manual.

    (Examples: Mild steel, low carbon steel, galvanized steel, aluminum, high-strength steel)

  - c. Note type(s) of damage.
  - d. Check panel alignment with adjacent panels.

- 2. Plan repair
  - a. Determine order of damage and order of repair.
  - b. Determine method(s) of repair.
- 3. Prepare surface for repair.
  - a. Clean panel.
  - b. Remove paint and other materials, as needed.
- 4. Roughout panel.
  - a. Restore metal to original alignment.
  - b. Restore metal to original surface contour, or at least close enough that body filler can be applied at a depth no greater than 1/4 inch.
- 5. Apply and finish body filler, if needed.
- 6. Restore corrosion protection.
- 7. Refinish surface.

H. Analyzing damage

- 1. Analyzing the damage is a critical step in panel repairs.
- 2. The proper method of repair can only be determined if the damage is correctly analyzed.
- 3. In analyzing the damage, the technician must determine if the panel can be repaired.
- 4. A non-repairable panel is a panel which either cannot be properly repaired, or a panel which cannot be economically repaired.
  - a. If the damage is so extensive or severe that the required strength of the panel cannot be restored, then it will be replaced.
  - b. If the estimated labor and materials involved in repairing the panel equals or exceeds the estimated labor and materials involved in replacing the panel, then the panel will be replaced.

I. Understanding sheet metal damage

1. Effects of bending sheet metal (FIG. 1-1)

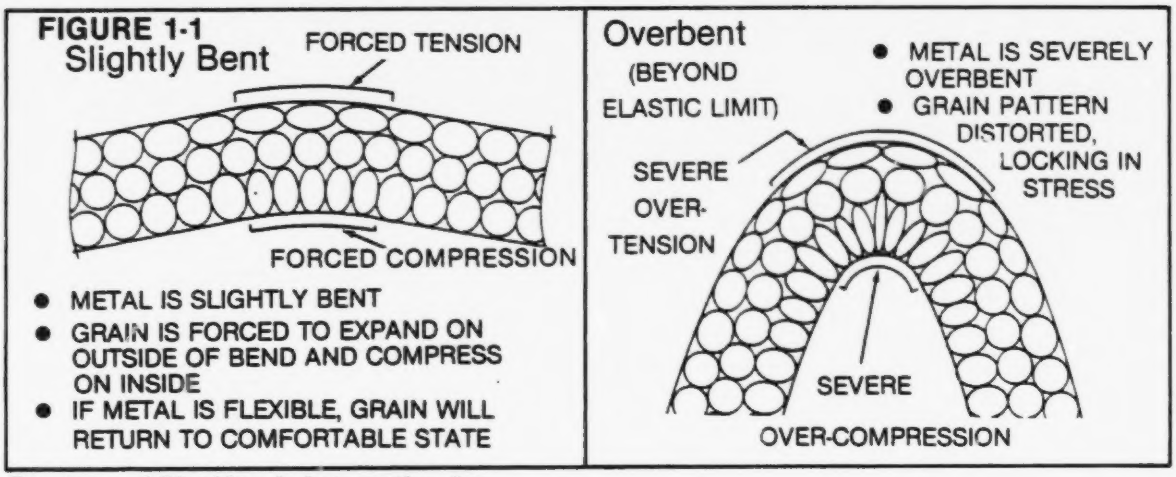


FIGURE 1-1

Slightly Bent

- METAL IS SLIGHTLY BENT
- GRAIN IS FORCED TO EXPAND ON OUTSIDE OF BEND AND COMPRESS ON INSIDE
- IF METAL IS FLEXIBLE, GRAIN WILL RETURN TO COMFORTABLE STATE

Overbent (BEYOND ELASTIC LIMIT)

- METAL IS SEVERELY OVERBENT
- GRAIN PATTERN DISTORTED, LOCKING IN STRESS

Courtesy of Blackhawk Automotive, Inc.

   a. Surface on outside of bend becomes stretched

   b. Surface on inside of bend becomes upset (compressed)

2. When metal is bent it becomes harder

   a. The effect of bending metal, thereby making it harder, is called work-hardening.

   b. All metal is work-hardened when it is formed into vehicle parts. The more bend is given to the metal the harder it becomes (provided the metal is not stretched or compressed beyond its yield point.)

   c. Metal also becomes harder when struck with hammer blows, such as in making repairs.

   d. Work-hardened metal is under stress. If the work hardening is a result of the accident and must be removed, then stress relief must be performed.

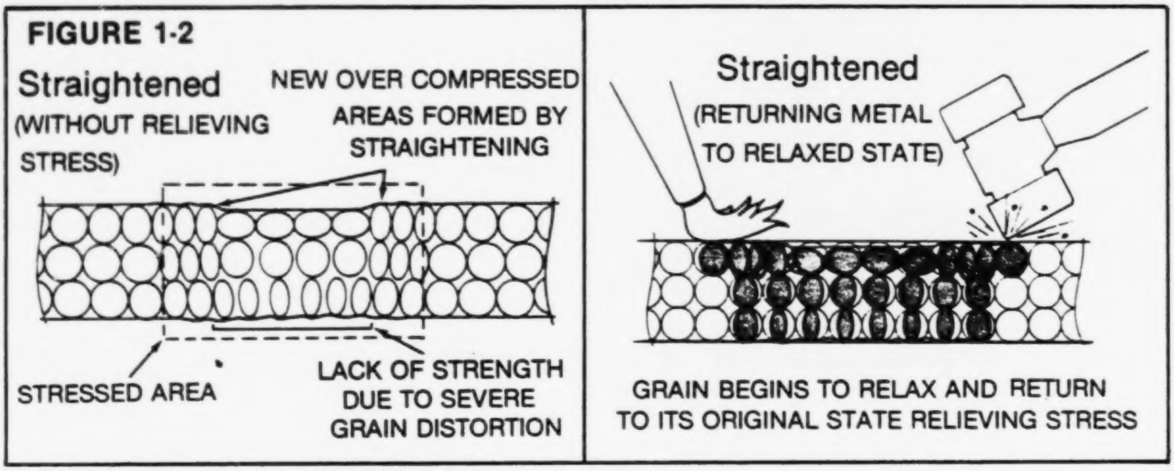
3. There are two types of stress relief -- heat and shock.

   a. Heat relief is accomplished by heating the metal with an oxyacetylene torch (within the guidelines of the metal being heated)

   (CAUTION: *Do not heat metal until you know the exact type of metal being worked on and the limit to which it can be heated. High strength steel has very specific heating limitations.)*

b. Shock relief is accomplished by striking the metal with a hammer while pressure is applied (such as with a hydraulic body jack). (FIG. 1-2)

FIGURE 1-2


Straightened
(WITHOUT RELIEVING STRESS)
NEW OVER COMPRESSED AREAS FORMED BY STRAIGHTENING
STRESSED AREA
LACK OF STRENGTH DUE TO SEVERE GRAIN DISTORTION
Straightened
(RETURNING METAL TO RELAXED STATE)
GRAIN BEGINS TO RELAX AND RETURN TO ITS ORIGINAL STATE RELIEVING STRESS

Courtesy of Blackhawk Automotive, Inc.

(NOTE: Stress relief is a critical matter for structural panels. See Module 7 - "Frame-body and Unibody Construction and Repair," for more guidelines.)

4. Key properties of metals allowing them to change shape:

   a. Plasticity -- The ability to be forced into a new shape without breaking. When sheet metal is formed in a press, it is said to have undergone plastic deformation -- meaning that under pressure the metal has flowed into a new shape.

      (NOTE: Work-hardened metals retain plasticity, but the degree of their plasticity has been changed)

   b. Yield point -- The point at which metal will stop flowing under pressure and will break.

   c. Ductility -- The ability of metal to be stretched without breaking.

   d. Malleability -- The ability of metal to be compressed (upset) without breaking.

   e. Elastic limit -- The amount of bending metal can undergo without undergoing deformation.

5. Analyzing repairs

   a. In analyzing repairs one of the most important aspects is to diagnose where the bending has occurred and how much the metal has been bent.

b. Metal which has been bent but which has not undergone deformation is said to have "oil-canned."

(NOTE: The term comes from the ability of the metal at the bottom of an oil can to be pushed inward and still spring back out.)

c. In damage to metal panels it is common for some areas to "oil can" due to damage to adjacent areas of the panels. In making repairs, the technician must recognize areas that have oil canned, planning repairs such that when the stresses have been relieved on the damaged areas, the oil canned areas will return to the their correct shape with little or no direct pressure applied.

(NOTE: Trying to straighten an oil-canned area with direct pressure will result in additional damage to the panel.)

d. In assessing the damage, the point of impact and the direction of impact must be assessed. In removing damage, the damage is generally removed in the OPPOSITE SEQUENCE in which it occurred, using the principle of "Last-in, First-out."

III. Classifying and repairing damage

A. Damage to metal panels is of three basic types

1. Tears
2. Holes
3. Bends

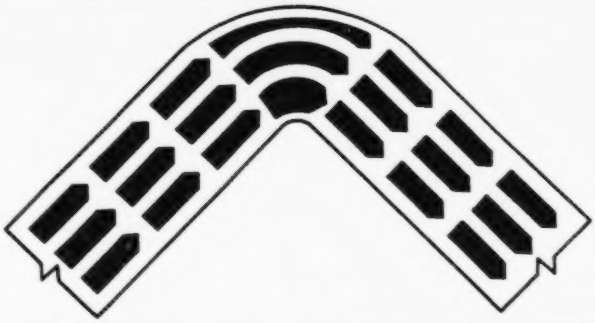
B. Tears and holes occur when the metal has been stretched beyond its yield point. Smaller tears and holes will not greatly effect the overall strength of the panel and can be repaired by patching or filling.

C. Bends occur when the metal has been stretched or compressed beyond its elastic limit. Bends must be repaired by carefully working the metal back into shape, using various methods, covered later in this unit. The bend is sometimes called the "buckle."

D. The complex shapes used in the design of most vehicle panels result in complex buckles in a collision.

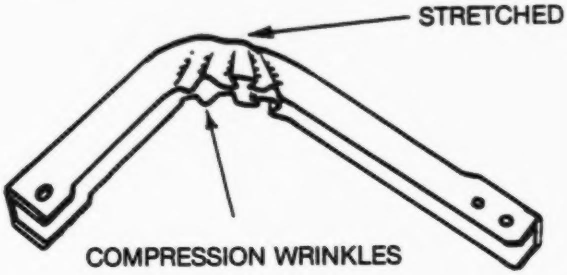
1. A flat surface, when bent, results in stretch at the top of the bend and compression at the bottom. (FIG. 1-3)

FIGURE 1-3



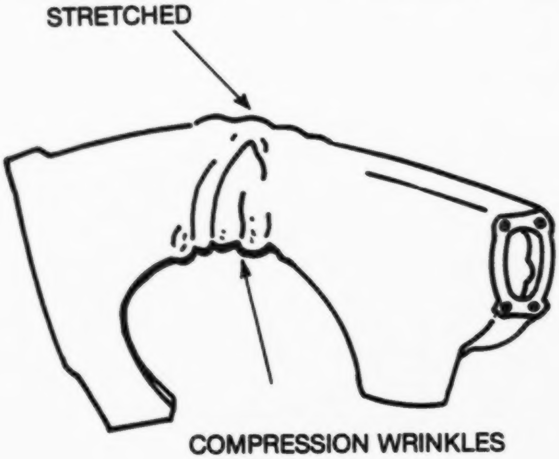
2. A open box section component, when bent, results in simple stretch at the top of the bend and compression wrinkles at the bottom. (FIG. 1-4)

FIGURE 1-4


STRETCHED
COMPRESSION WRINKLES

3. Because of the complex curves in auto body parts, they tend to resemble partial box sections. When damaged, they have areas of stretch and areas of compression wrinkles. (FIG. 1-5)

FIGURE 1-5

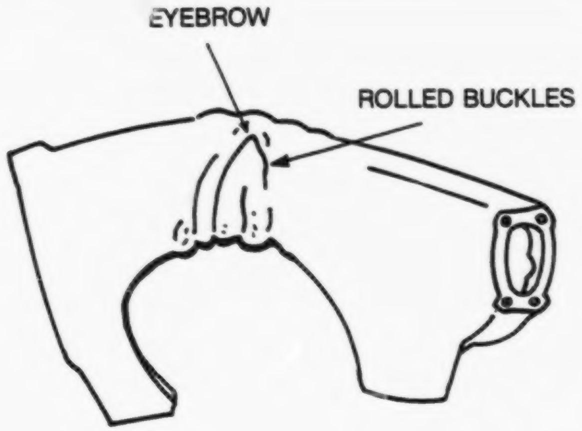

STRETCHED
COMPRESSION WRINKLES

4. Actual damage to vehicle panels generally results in compression wrinkles of two types, known as "rolled buckles," and "hinge buckles."

   a. Rolled buckles usually occur in areas where the metal has a crowned surface. In a rolled buckle all of the metal along the buckle has been stretched and compressed.

   b. Rolled buckles tend to end at some point in the crown with a sharp dent. The ridge above this dent is call an "eyebrow." (FIG. 1-6)

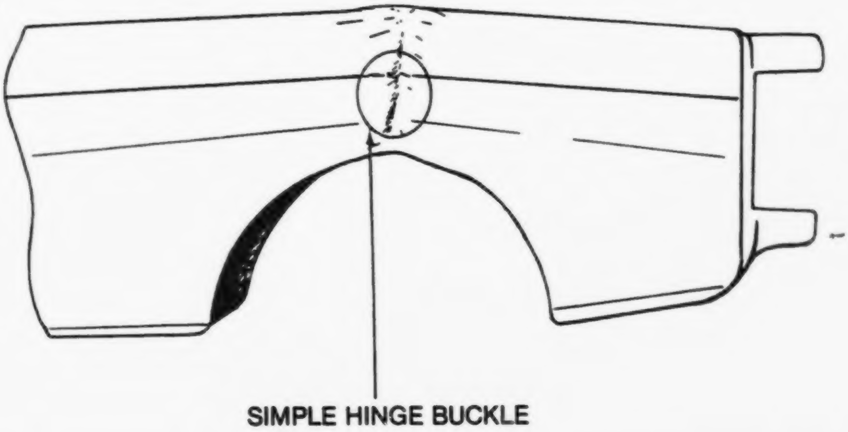
FIGURE 1-6



(NOTE: In modern vehicle design, most panels have a variety of crowned surfaces)

   c. Hinge buckles occur as a bending or pivot point from which two areas of relatively undamaged metal have moved or shifted. (FIG. 1-7)

FIGURE 1-7



E. Direct and indirect damage

1. Damage in a collision may be the result of direct (primary) damage or indirect (secondary) damage.

2. Primary damage is damage which is the direct result of the collision force at the point of impact and the immediately surrounding area.

3. Secondary damage is damage that results to surfaces which have been forced to change shape due to the pressure resulting from the primary damage.

   (NOTE: As the primary damage changes the shape on one area of a panel, other areas of the panel are forced to change shape as well. If the damage is severe enough, the panel may push or pull on adjacent panels, causing secondary damage to those panels. Secondary damage, especially in the case of modern unibody vehicles, can occur in areas of the vehicle far removed from the area of primary damage.)

F. Repairing damage

1. In repairing damage, visualize how the damage occurred.

   a. Carefully assess the damage, looking for areas of primary and secondary damage.

   b. Reconstruct the accident, noting the area and direction of primary damage, and the areas of secondary damage.

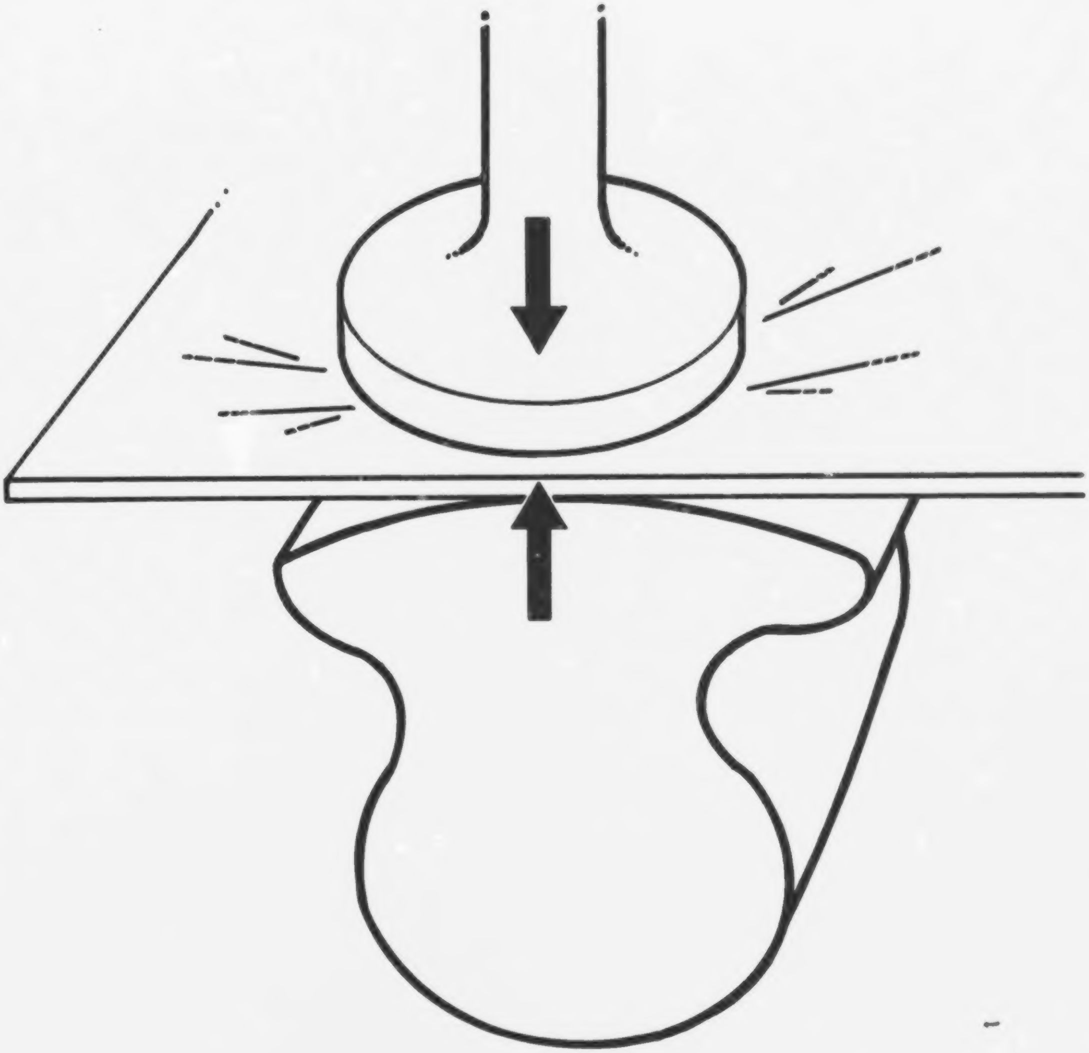
2. After reconstructing the way the damage occurred, plan a repair sequence which will take out the damage in the reverse order in which it occurred.

   (NOTE: All damage should be removed is the opposite direction in which it occurred. The last damage which occurred in the accident should be taken out first. This is known as the reverse sequence rule.)

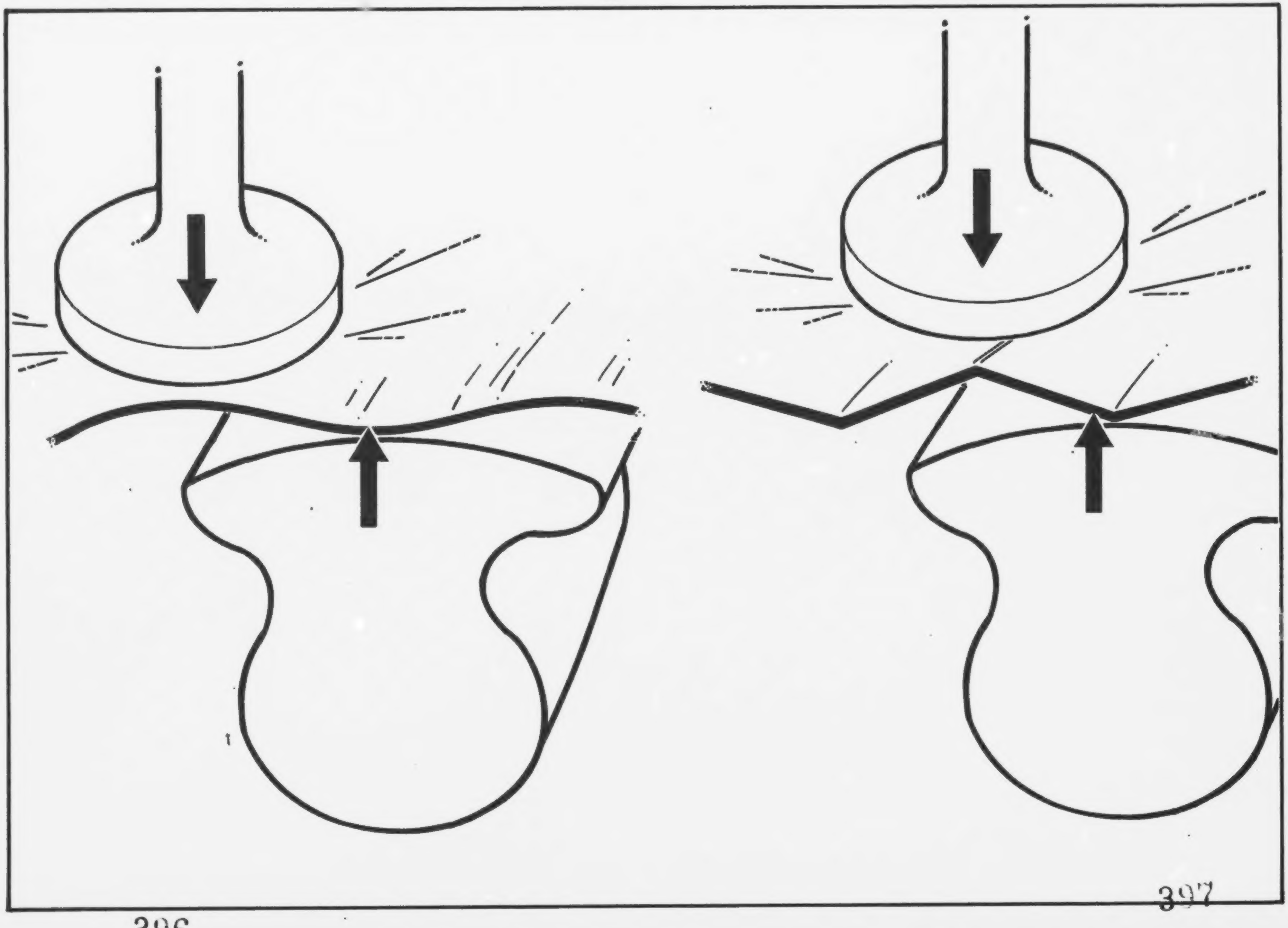
3. The complexity of the repair method will depend on the complexity of the damage. In some cases there may be only one relatively simple step in roughing out the panel. In other cases a number of different methods and many different steps may be required to perform the roughout procedure.

   (NOTE: Repair methods are covered in Lesson Two.)

Hammering On the Dolly



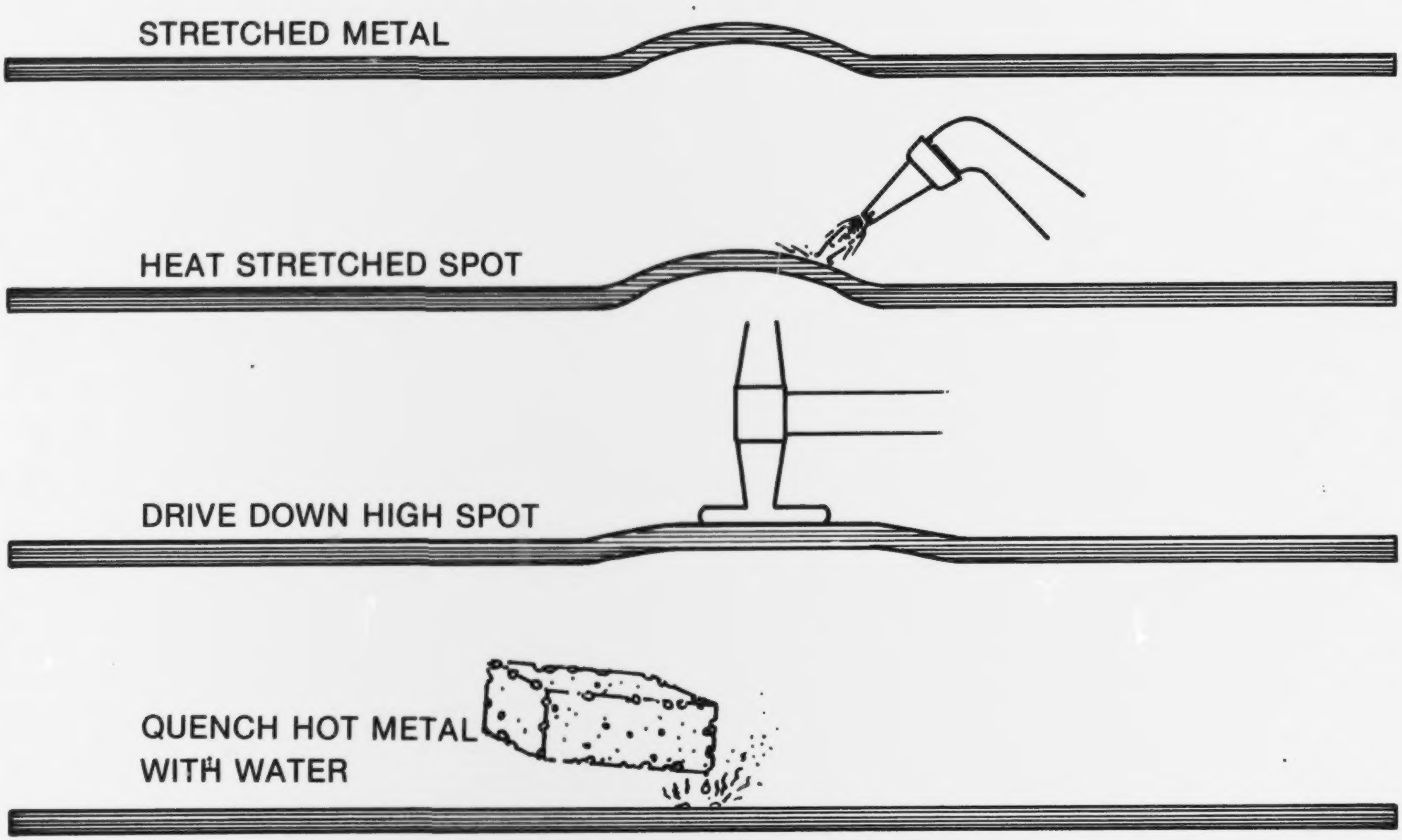
Hammering Off the Dolly



TM 2

I-PANELS - 17

Shrinking



STRETCHED METAL

HEAT STRETCHED SPOT

DRIVE DOWN HIGH SPOT

QUENCH HOT METAL
WITH WATER

TM 3

UNIT I

JOB SHEET #1, LESSON ONE

ANALYZE DAMAGE

Equipment:

Eye protection
Steel tape measure
Tools as required to gain access to damage
Vehicle specification manual

(NOTE: This job sheet is a steps of procedure for the student and an evaluation device for the instructor. However, the student will have to have a notebook to record observations. The instructor can use this job sheet to evaluate the student's observations.)

Procedure:	**Evaluation:** 3	2	1	N
1. Put on eye protection and examine the exterior and interior of the panel(s) and classify damage type(s).	___	___	___	___
2. Check gaps between adjacent panels to see if misalignment has occurred.	___	___	___	___
3. Establish the point of impact and the direction the damage was applied.	___	___	___	___
4. Locate direct damage areas.	___	___	___	___
5. Locate indirect damage areas.	___	___	___	___
6. Determine the starting point for repairs.	___	___	___	___
7. Determine the method of repair and the sequence of repair. *(NOTE: Remember the reverse sequence rule.)*	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency G1 "Analyze damage.")

MODULE: PANEL REPAIRS

UNIT I: SHEET METAL REPAIR AND ROUGHOUT

LESSON TWO: ROUGHOUT

I. **Terms and definitions**

A. Body spoon -- A specially designed dolly with a handle. It is used in spring hammering, and also as a dolly in situations where there isn't enough room to reach the back side of a panel with a dolly.

B. Bumping hammer -- Any of several specially-designed hammers used to straighten sheet metal.

C. Hammer and dolly -- Using body hammers, spoons and dollies to roughout metal damage that is not severe; often used on any remaining high or low spots after other metal straightening methods have been used.

D. Hammer-off-dolly method -- Holding the dolly on the backside of the panel not directly under blows from a body hammer.

E. Hammer-on-dolly method -- Holding the dolly on the backside of the panel directly under blows from a body hammer.

F. Heat shrinking -- Using an oxyacetylene torch, a body hammer and dolly, to expand and shrink stretched metal.

G. Pick hammer -- A body hammer with a tapered, blunt chisel on one end of the head, and usually a bumping face on the other end. Used to lower a crease or a small dent in sheet metal.

H. Power body jack -- Hydraulic ram and attachments used to rough out or align large wrinkled or collapsed damage by either pushing or pulling metal back to its proper shape and dimensions. Some power jacks may be mechanically operated, but most are air operated.

I. Pry bar -- Any specially designed long metal bar used to pry out metal damage in situations where the back of the panel in inaccessible. Also known as pry picks.

(NOTE: Pry bars or picks are especially useful in difficult-to-reach areas. Care must be taken so that metal is not pried out too far, causing the metal to stretch.)

J. Pull tabs and rods -- Special metal devices welded onto panels which can then be used as pulling points for straightening damage to panels. Although their use is decreasing due to the use of high strength steel, they are still used in some situation.

K. Quenching -- Using a water-soaked sponge or rag to rapidly cool a heated panel in heat shrinking metal.

L. Slide hammer -- A special tool used to pull out dents and to relieve pressure on metal damage that is inaccessible from behind. The slide hammer has a weight which can be moved along the barrel of the hammer and rammed into a stop at either end of the barrel.

M. Spring hammering -- Technique used on high crown or eyebrow dents to return metal to its original contour without creating hammer marks. Done by placing a flat body spoon over the ridge and using a body hammer to drive down atop the spoon.

N. Vacuum cups -- Suction cups which can be attached to a clean, wet, metal surface to pull out low-crown dents where the metal has oil canned, but not deformed.

II. Roughout techniques

A. Roughout is the stage in auto body repair in which correct dimensions are established to make sure that all panels fit and match up properly.

(NOTE: The term "roughing out" is somewhat misleading. The dimensions must be very accurate, even if the metal panels still look rough prior to metal finishing operations.)

B. Due to the unique nature of each collision, there is no "one" way to roughout panels.

1. There are no clear cut dividing lines between the operations of roughing out, panel alignment and metal finishing. There tends to be considerable overlap.

   (NOTE: Generally, the term "roughout" refers to the process of re-shaping damaged panels into approximately their original contours and original alignment. Each situation will require a unique combination of methods. In the case of moveable panels repaired off the vehicle, correct alignment is performed after roughout procedures.)

2. Each situation must be assessed on its own merits and a repair procedure must be determined.

C. Methods of roughing out panels

(NOTE: See Module 1 "Introduction to Auto Body," for a complete description of the tools listed below.)

1. Using body hammers, spoons and dollies -- Used in many repairs as the final procedure prior to plastic filling, regardless of which other methods are employed. Body hammers, spoons and dollies are also tools that are used in performing other methods of repair.

2. Using pry bars -- Used in situations where the back of a panel is not accessible.

3. Using pull rods or slide hammers -- Used in situations where the back of the panel is not accessible and pry bars are inadequate.

4. Using pull tabs -- Used in some situations (depending on the type of metal) where there is severe damage.

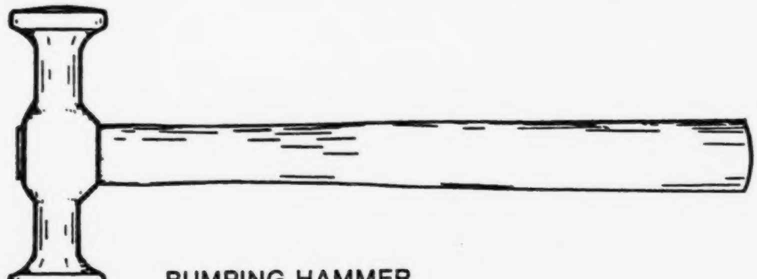
5. Using hydraulic equipment -- Often used on quarter panels, and some other stationary panels, as a first step in returning a severely damaged panel back to its proper dimensions.

   (NOTE: In repairing the damage to any panel, the damage must be repaired in the opposite sequence that it occurred. The last damage caused by the collision is the first damage that should be removed. For a more complete discussion of the "Last in-first out" principle as relates to unibody vehicles, see Module 7 on frame and unibody repair.)

D. Using the hammer and dolly method

1. The hammer and dolly method is the most common method of roughing out panels.
2. Body hammers, spoons and dollies are used in this work.
3. Body hammers are designed to rebound off the sheet metal surface after striking it.
4. Use of these body hammers is not difficult, but it requires some practice. The technician must become accustomed to the different motion used in the quick tap technique of striking sheet metal.
5. The main goal in roughing out sheet metal damage should be to save the panel. Hard hammer blows cause new dents in the sheet metal. Light, rebounding blows should be used to prevent additional damage to the panel.
6. Using body hammers (FIG. 2-1)

FIGURE 2-1



BUMPING HAMMER

   a. The right body hammer must be used for the job and mastery of using the hammer with the dolly must be achieved.

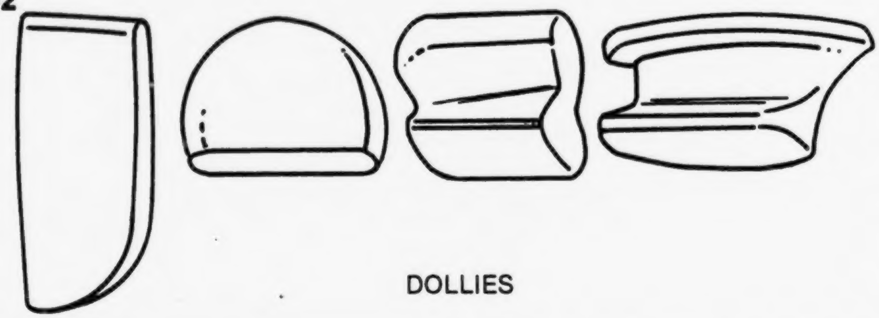
      (NOTE: Body hammers should be well-cared for and not used for any purpose other than their intended purpose. Do not use them as ordinary hammers.)

   b. In using body hammers the blows struck should be light and even and not heavy. If the metal is workable, it will come back into shape with finesse instead of brute force.

c. In striking a blow, the body hammer should be held loosely in the hand by the end of the handle, and it should spring back from the metal as the blow is struck.

E. Using dollies and spoons (FIG. 2-2)

FIGURE 2-2



1. Dollies are used together with body hammers in straightening panel damage where the back of the panel is accessible.

2. The dolly is held in the hand against the backside of a low spot, while the hammer is tapped on a high spot on the other side.

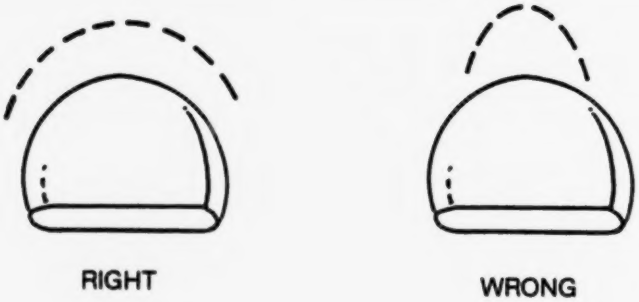
3. There are two types of hammering with a dolly.

   a. Off-the-dolly hammering

   b. On-the-dolly hammering

4. Dollies come in various shapes, to fit the various contours of panels, in order to bring the panel back to its original contour. The radius of the dolly should be smaller than the the radius of the desired contour of the metal. (FIG. 2-3)

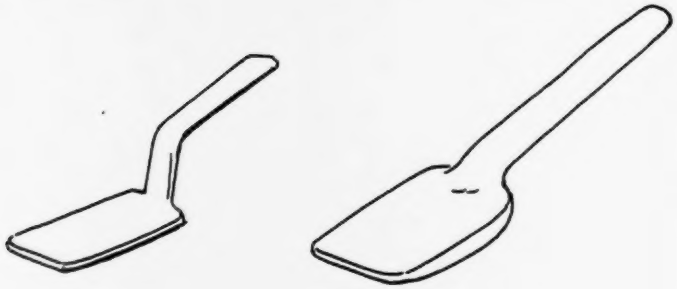
FIGURE 2-3



5. Dollies are made of high-grade steel and are available with high, medium, low and flat crowns, or a combination of several crown working faces.

6. Body spoons are also called dolly spoons because they are used in much the same way as a dolly. (FIG. 2-4)

FIGURE 2-4



BODY SPOONS

7. Body spoons are essentially dollies with handles which allows them to be used in places you cannot reach with a dolly.

8. Body spoons are also used to spread the blow of the hammer over a large area by using a flat body spoon that can be laid down along a long ridge.

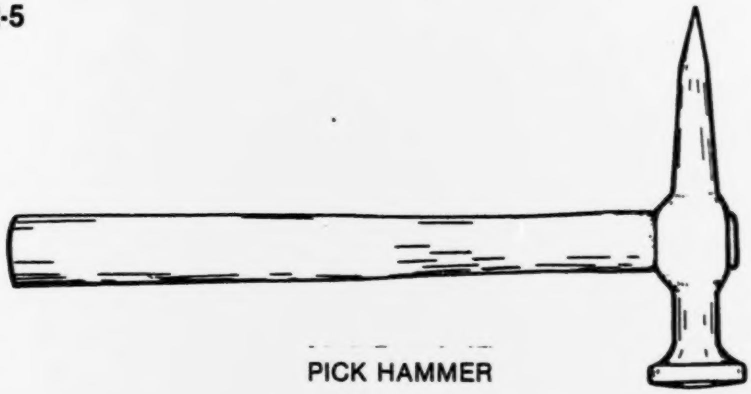
9. Body spoons are also used as heavy-duty prying or driving tools, prying or driving against low spots to work them out.

10. Body spoons are used in spring hammering, where the spoon is laid across a high crown or ridge and a ball peen hammer is then driven down on top of the spoon.

(NOTE: Do not use a body hammer for any type of hammering on spoons. It will damage both the spoon and the body hammer.)

F. Using pick hammers (FIG. 2-5)

FIGURE 2-5

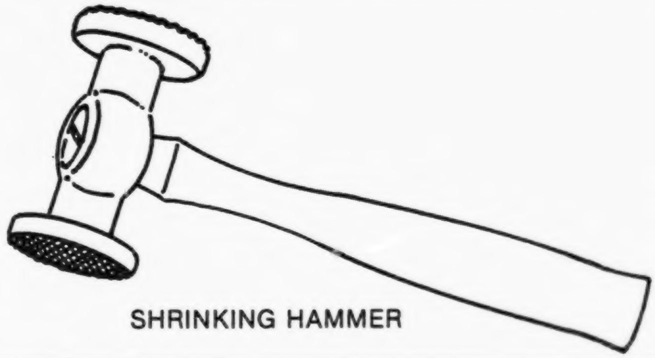


PICK HAMMER

1. Pick hammers have a tapered, blunt chisel on one end of the head, and usually a bumping face on the other end.
2. Pick hammers are used to lower a crease or a small dent in the metal.
3. Pick hammers may be used with or without a dolly.

G. Shrinking hammers (FIG. 2-6)

FIGURE 2-6



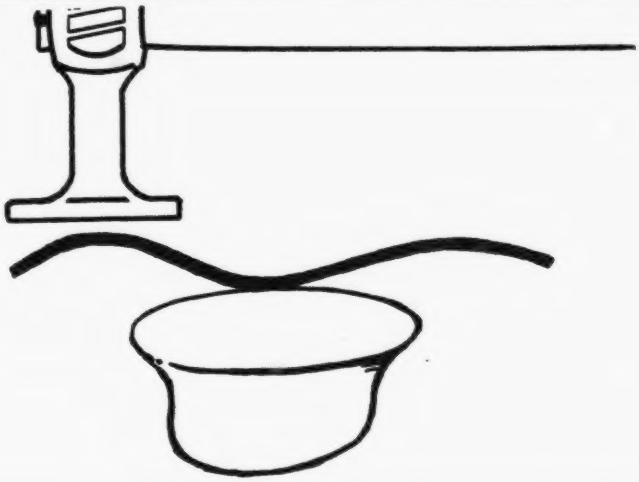
SHRINKING HAMMER

1. A shrinking hammer is another type of body hammer used to shrink metal.
2. Shrinking hammers are distinguished by having two serrated faces, both round, or one round and one square.
3. They are used to bring lightly stretched metal back into shape.
4. The serrated edge "grips" the metal, and as the hammer lowers a high spot (always backed by a dolly) the metal is compressed back into shape.

H. Hammer-on-dolly and hammer-off-dolly methods

1. Hammer-off-dolly method (FIG. 2-7)

FIGURE 2-7



a. Used to relieve strain where light force is required

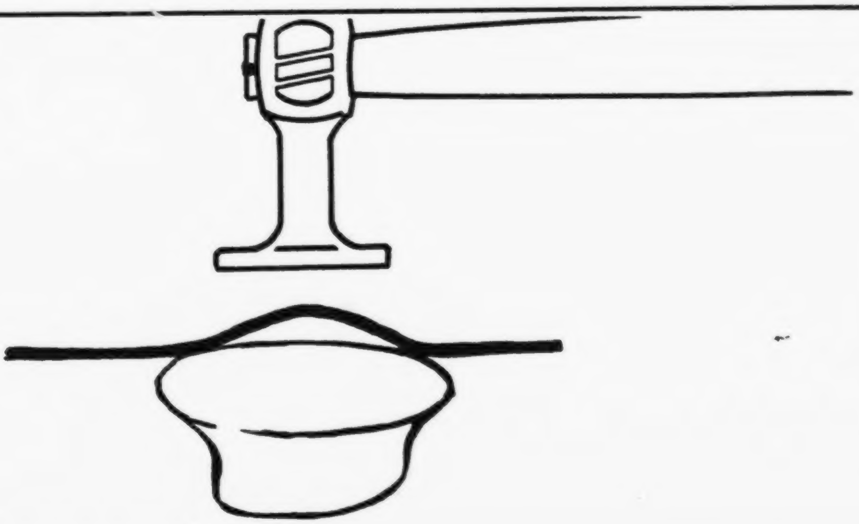
b. Used to rough and level the panel prior to using the hammer-on-dolly method.

c. Dolly is held on a low spot on the backside of the panel and the hammer is struck on a high spot on the front side of the panel.

d. Does not compress the metal beneath the hammer blows

2. Hammer-on-dolly method (FIG. 2-8)

FIGURE 2-8



a. Used to finish a panel to original contour after hammer-off-dolly method has been used (if needed)

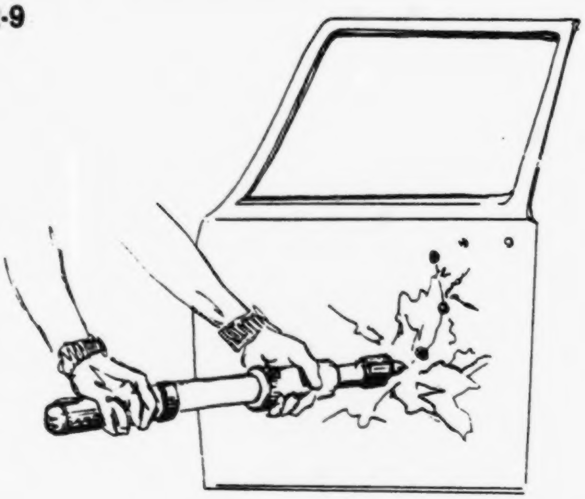
b. Compresses the metal directly between the hammer and the dolly.

c. Use a straight edge to determine if panel is conforming to original contour for both hammer-on and hammer-off.

d. Do not use extreme force if the metal resists for both hammer-on and hammer-off. (Re-analyze the damage; a different technique may be necessary. Too much force will stretch or work harden the metal.)

I. Slide hammers (FIG. 2-9)

FIGURE 2-9



SLIDE HAMMER

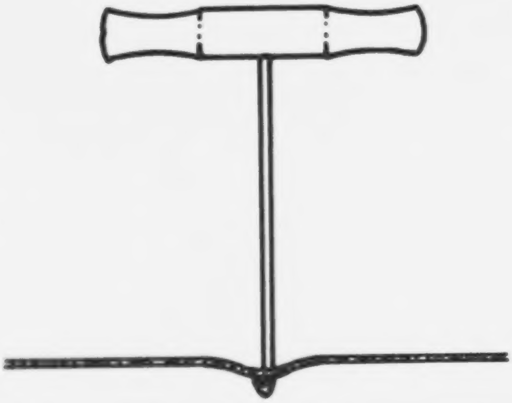
1. The slide hammer has a weight that can be rammed against a stop at the end of a cylinder that the weight slides along.
2. Using various attachments the slide hammer can pull on a damaged panel.
3. One way of using a slide hammer is to drill a small hole into a panel which must be pulled out, then fasten a sheet metal screw into the hole. The slide hammer is then attached to the sheet metal screw and the slide weight is used to pull the panel outward.
4. Another way is to use a weld-on stud gun to provide an attachment point for the slide hammer (see below).
5. The advantage of the slide hammer is that the back of the panel does not have to be accessible.

6. The slide hammer must be handled carefully, again using finesse instead of brute force. In the proper operation of the slide hammer, two or more screws will be fastened to the panel and the slide hammer will be moved from one to the other as the pull progresses.

7. The slide hammer can also be used with a suction cup attachment to pull out a panel, or with various hooks to grab onto the edge of a panel, or with attachments which allow it to push against a panel.

J. Pull rods (FIG. 2-10)

FIGURE 2-10



1. Pull rods are used in much the same way as a slide hammer, but are used on smaller areas of damage.

2. To use a pull rod, a hole is drilled in the damaged panel and the hooked end of the pull rod is inserted into the hole. The technician then pulls on the handle of the pull rod in an attempt to pull the dent out.

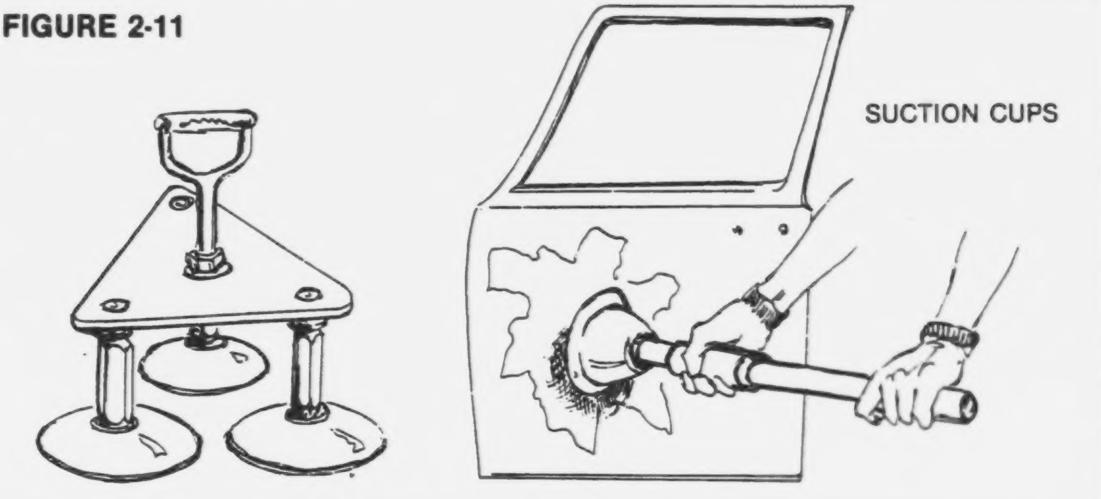
3. Often, more than one pull rod is used at the same time to distribute the pressure of the pull over a broader area. However, the holes drilled must be close enough together than the rods can all be grasped firmly at the same time.

4. In using both pull rods and slide hammers a bumping hammer may be used to tap on the edges of the depressed area to help relieve the stress in the metal and make the pull easier.

5. One disadvantage to pull rods and slide hammers is that they raise the metal around the rim of the drilled holes and this metal must them be shrunk or filed off.

K. Suction cups (FIG. 2-11)

FIGURE 2-11



1. Suction cups can be used to pull out large, shallow dents, where the metal has not buckled.

2. The suction cups are wetted and the surface wetted, then pushed in at the center of the depression, expelling the air from the cup.

3. A configuration of two or three suction cups is often used.

4. Suction cups can also be used with frame straighten equipment. For pulls on the hood, roof and deck, a motor hoist can be used with the suction cups.

5. If the suction cups work properly and the metal has not been upset, then the dent should "pop" out.

L. Special pry bars

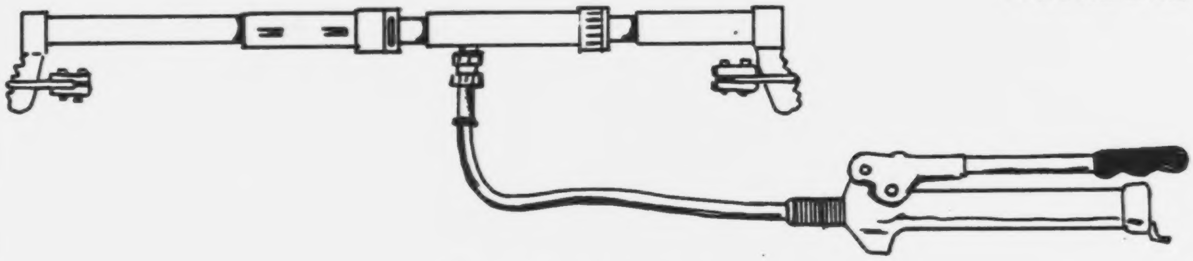
1. Some pry bars are made which can get into hard-to-reach places.

2. For example, some can be pushed up inside of drain holes to get access to the back of a panel where no other access is possible.

3. Your instructor can demonstrate any special pry tools you have in your shop.

M. Hydraulic body jacks (FIG. 2-12)

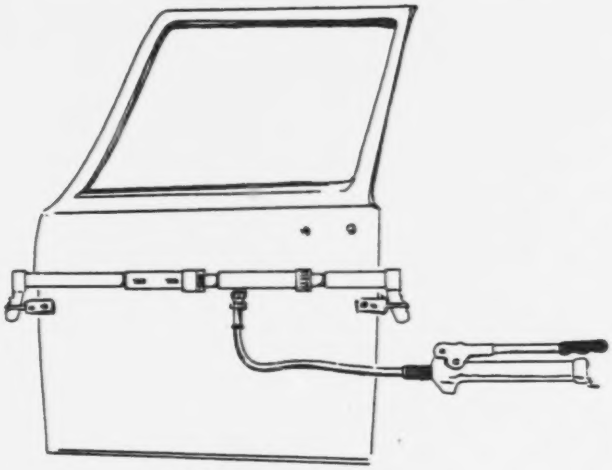
FIGURE 2-12



HYDRAULIC BODY JACK

1. In working with larger areas of sheet metal damage, hydraulic tools may be used to restore the panel or panels to their original length or width.
2. Hydraulic body jacks are used in situations of light-to-moderate damage to panels, where the damage is too great to be fixed with hand tools.
3. Hydraulic body jacks are used in the following situations:
   a. When one panel can be straightened by grabbing opposite ends of the panel and pulling or pushing (FIG. 2-13)

FIGURE 2-13



DOOR PULL

   b. Where a panel can be straightened by pushing or pulling against an adjacent panel
4. Great care must be taken in using hydraulic body jacks
   a. There is tremendous force in these tools, which must be respected at all times.

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b. When pushing body panels apart or pulling them together, great care must be taken that undamaged panels are not damaged.

(NOTE: It is better to use frame straightening equipment to straighten damaged panels in many situations. Frame straightening equipment can be set up in such a way that only the damaged panel will receive any force. Although hydraulic body jacks take less time to set up than frame straightening equipment, they can cause damage to the vehicle if not used properly.)

5. Various types of attachments are available for the hydraulic body jack

a. Clamps and chains for pulling operations

b. Hooks for pulling operations

c. "Foot" attachments for pushing operations

d. Spreader attachments for spreading apart panels which have been crushed together.

(NOTE: Hydraulic rams are also used in frame straightening systems. See Module 7 for a detailed discussion of frame straightening systems.)

6. Safety

a. Make sure the ram is properly secured when pulling or pushing.

b. Make sure any extensions or attachments are properly attached and the threads are not damaged.

c. When operating a body jack, stay as far away from the jack as possible and do not stand in a direct line of the pressure being applied.

d. If using chain attachments, wrap the chains or bolt on a safety chain if the chain is long enough that it could damage the vehicle of the operator if it snaps.

e. Always wear safety glasses when operating hydraulic body jacks. The pressure of the ram may cause vehicle parts to break and fly off with enough force to put out an eye.

f. If using body jacks in an area where vehicle glass is present, either remove the glass or tape the glass so that if it breaks the glass will not fly through the air.

N. The weld-on stud gun

1. The weld-on stud gun is an innovation with extensive applications in metal panel repairs.

2. In using the stud-gun, studs are welding onto damaged panels at the needed locations. The special weld is accomplished at low heat, safe for high strength steel.

3. Slide hammers (sometimes called slide knockers) are used to pull on the welded-on studs.

4. The studs are easily cut off afterward, and the weld is easily dressed down.

5. The advantage is that no holes are left to be filled and there is less chance of damaging the panel.

6. Procedure for using weld-on studs

   a. Determine center of damage.

   b. Clean and grind area.

   c. Weld a series of studs in locations needed (often right down a crease).

   d. Hook onto studs in proper sequence with slide hammer and remove damage. (Often the sequence will involve started at alternating ends of the crease and working toward the middle.)

   e. Cut off stud with side cutters and grind off head.

O. Straightening severe damage

1. Frame straightening equipment is often used when damage to panels is severe

2. Refer to Module 7 for procedures on using frame straightening equipment to straighten vehicle panels.

   (NOTE: One other method used on panel damage is pull tabs. However, the use of pull tabs in declining because they must be welded to the panel. Due to the thinner gauges of steel and the greater usage of high strength steel, welding the pull tabs to the panels can damage the panel.)

P. Heat shrinking

1. In addition to working with metals cold, heat shrinking is another often-used technique in roughing out panels made of low-carbon steel.

   (NOTE: Heat shrinking techniques will damage most types of high strength steel. Always be sure you know the type of metal you wish to shrink and follow the manufacturer's guidelines for heating the metal.)

2. Heat shrinking is accomplished on metal panels which include stretch damage to the metal. If the stretch is slight it may be worked out with cold shrinking techniques, but if severe stretching has occurred, heat shrinking may be an option.

3. Heat shrinking is not attempted until the panel has been roughed out using the other techniques outlined in this lesson.

   a. After roughout procedures have been used, an area of stretched metal will be revealed by a bulge in the metal, indicated that the metal has stretched too far.

   b. Heat shrinking works best on very small areas.

4. Why heat shrinking works

   a. When metal is heated, it expands.

   b. When metal cools, it contracts.

   c. When the metal is hot it can be worked with a hammer and dolly to return it to its original shape and granular structure.

   d. To further control the shrinking, the metal can be quenched with water.

   (NOTE: The faster the metal is cooled the more it will shrink.)

5. Equipment needed to heat shrink a spot on a panel

   a. Oxyacetylene torch

   b. Proper dolly or spoon

   c. Proper body hammer

   d. Pail of water and sponge or rag

   e. Safety equipment, including heavy gloves and welding goggles

   (NOTE: Safety is extremely important in heat shrinking. Not only must all safety rules be followed for oxyacetylene welding, but care must be taken to avoid burns from the hot metal and steam burns from the quenching process. STEAM CAN CAUSE VERY BAD BURNS.)

6. Procedure for heat shrinking

   a. Have all equipment at hand and be ready to work quickly.

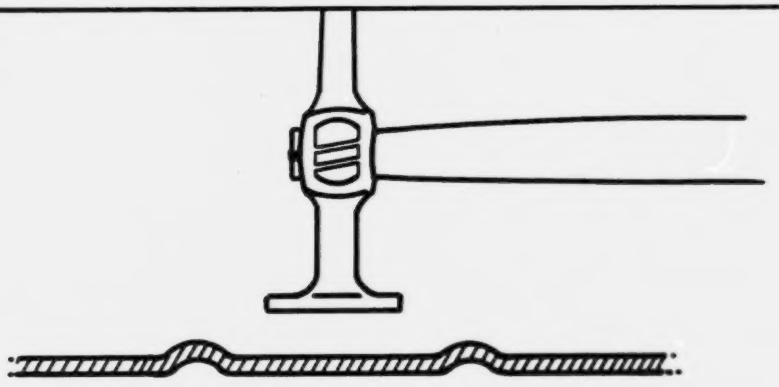
   b. Adjust torch to neutral frame.

   c. Hold inner cone of frame 1/2 inch from surface and heat a small area about the size of a dime until it is a dark cherry red. DO NOT OVERHEAT.

   d. Put aside torch as soon as metal reaches dark cherry red.

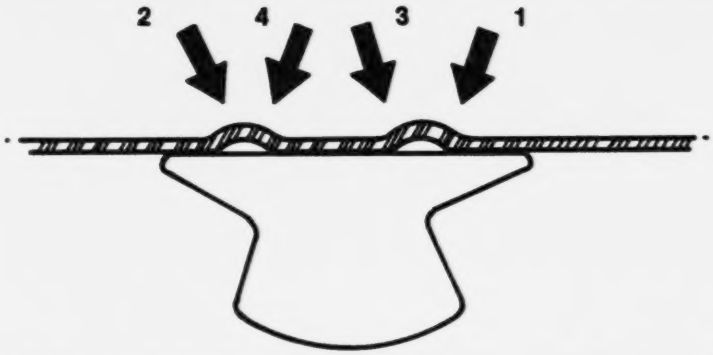
e. Using a body hammer, drive the center of the spot down. This will produce ridges along the outside edges of the area driven down. (FIG. 2-14)

FIGURE 2-14



f. Using a dolly with the correct contour, place the dolly behind the panel and drive down the ridges, using the striking pattern illustrated below. (FIG. 2-15)

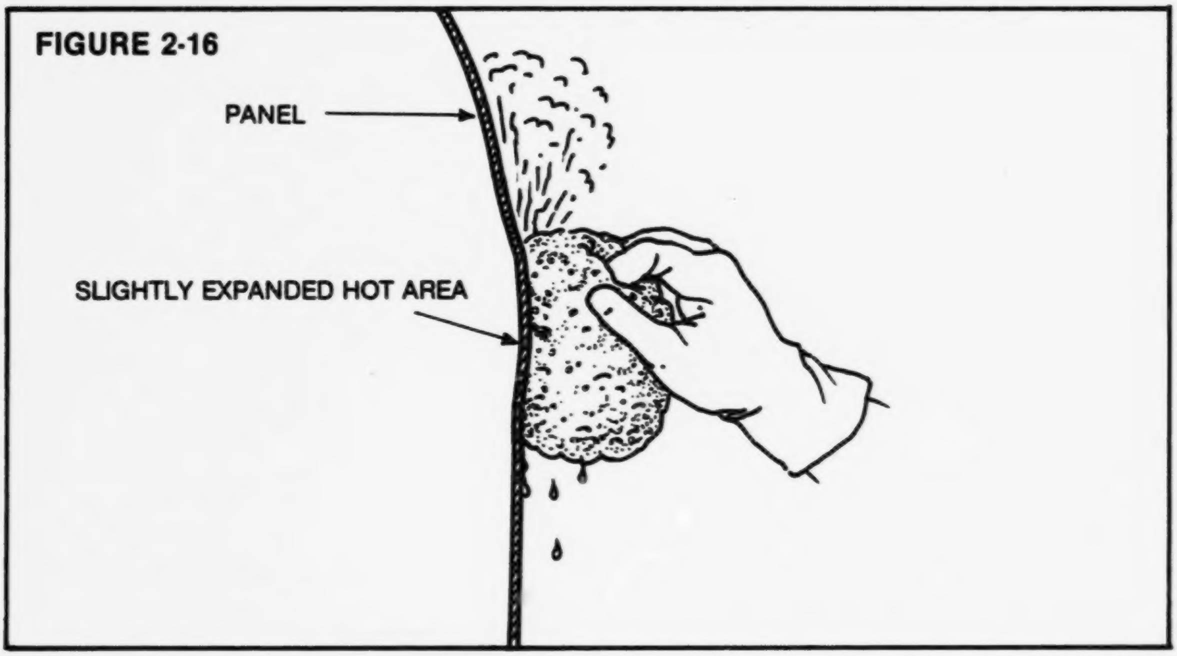
FIGURE 2-15



g. Although the spot should be shrunk considerably at this point, there will still be a tendency for a bulge.

h. As soon as the metal cools to the point that the color leaves, quench the area with water. This should shrink out the remaining bulge. (FIG. 2-16)

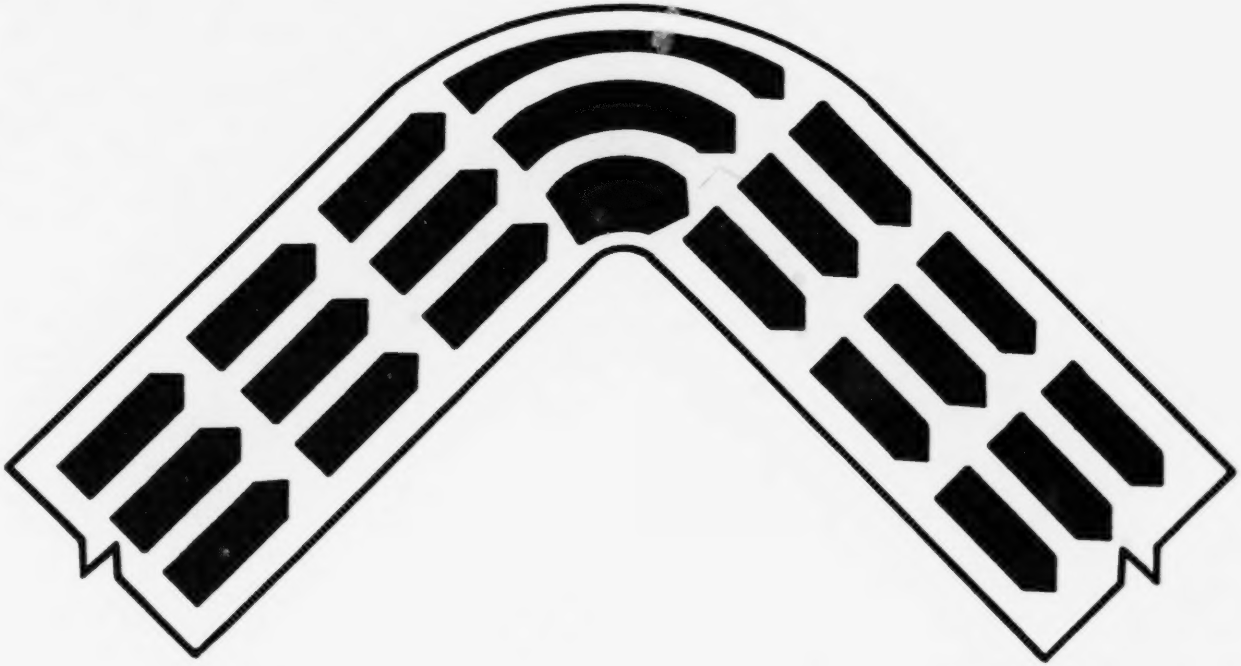
FIGURE 2-16



(CAUTION: *Quenching the metal when it is too hot will result in the metal crystallizing and becoming hard and unworkable. In some cases the metal could even crack.)*

i. If the area to be shrunk is a large area, heat only small spots, widely spaced; shrink the panel a little at a time. Heating too large of an area will cause warpage of the metal.)

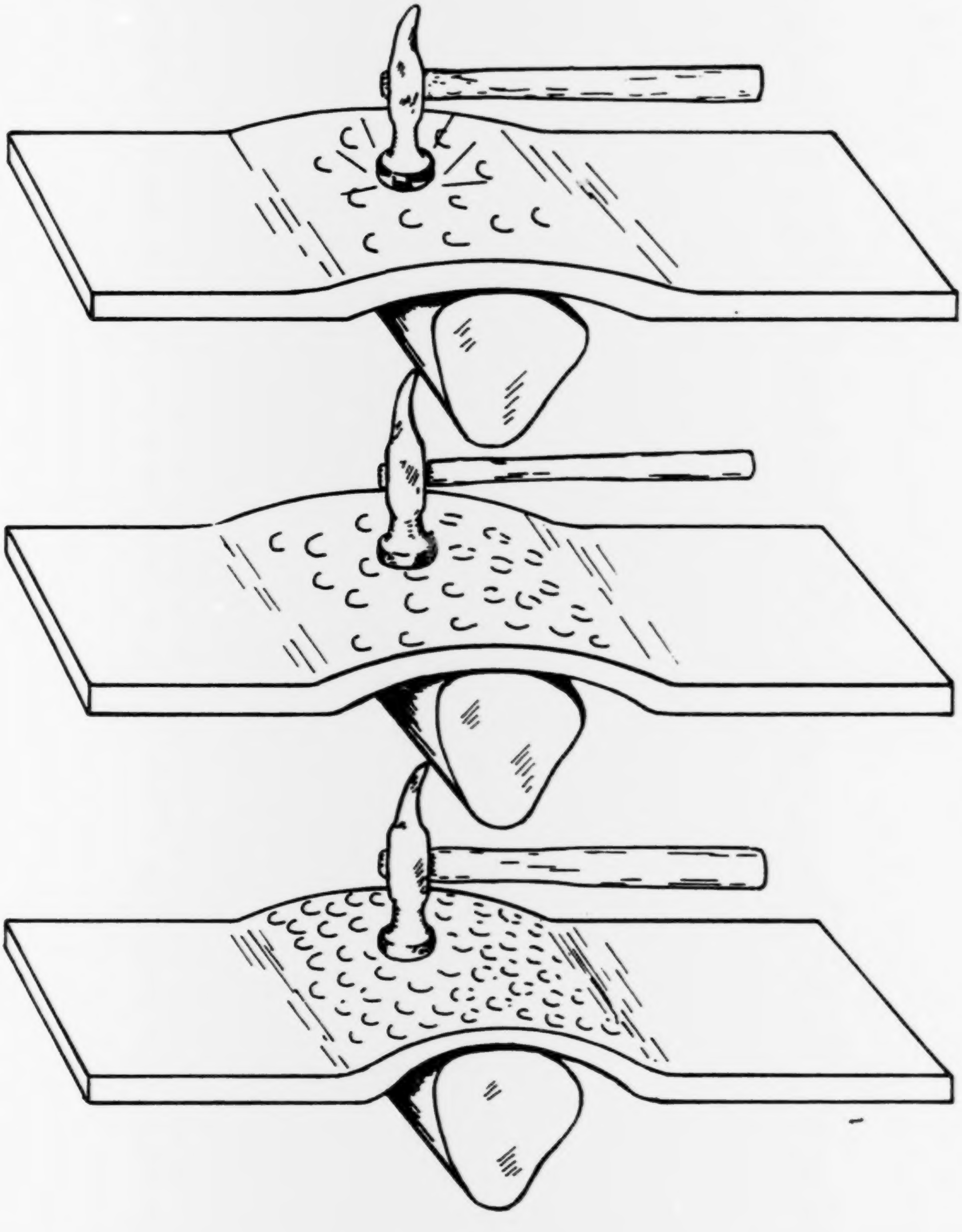
Effects of Bending Body Sheet Metal



A PIECE OF METAL, SEVERELY BENT, WILL STRETCH ON THE OUTER EDGE WHILE THE INNER EDGE WILL BECOME UPSET AND THICKER. THE CENTER REMAINS CONSTANT.

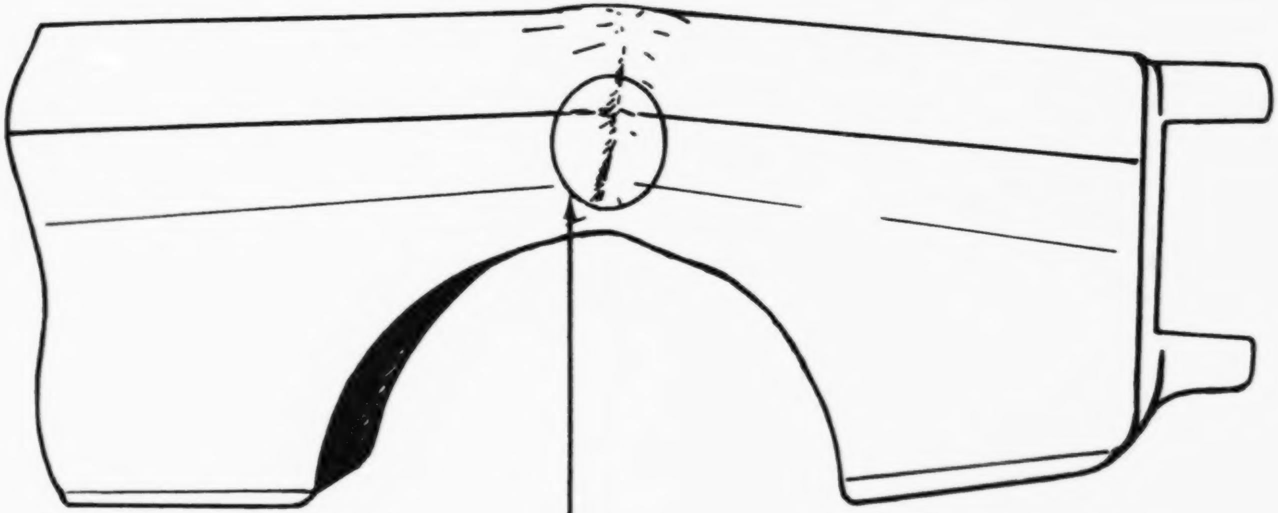
TM 1

Stretch



HARD HAMMER BLOWS CONTINUOUSLY WILL RESULT IN STRETCHED AND SEVERE WORK HARDENING OF THE METAL.

Hinge Buckle



SIMPLE HINGE BUCKLE

TM 3

UNIT I

JOB SHEET #1, LESSON TWO

CLEAN THE EXTERIOR SURFACE

Equipment:

Clean rags and towels
Degreasing solvent
Bucket and sponge
Detergent
Chamois

Procedure: **Evaluation:**

3 2 1 N

1. Wash panel. ___ ___ ___ ___

   (NOTE: Using the detergent with water in a bucket, sponge off panel using a firm motion to clean all dirt from the panel.)

2. Chamois panel dry. ___ ___ ___ ___

3. Degrease panel. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for Competency G2 "Clean the exterior surface.")

UNIT I

JOB SHEET #2, LESSON TWO

USE HAMMER AND DOLLY TO ROUGHOUT A PANEL

Equipment:

Appropriate body hammers
Appropriate dollies
Surface preparation equipment
Eye protection

(NOTE: The procedure in this job sheet is shown on a low crown panel. The same basic techniques can be used to rough out other types of panels.)

Procedure:	**Evaluation:** 3	2	1	N
1. Clean the panel by performing Job Sheet #1, this lesson.	___	___	___	___
2. Select the dolly that matches an undamaged part of the panel.	___	___	___	___
3. Apply pressure with the dolly by gently tapping it to the back side of panel.	___	___	___	___
4. To relieve stress, use light force with a finishing hammer using the hammer-off dolly method.	___	___	___	___
5. Use straight edge to determine if panel is conforming to original contour.	___	___	___	___
6. Use hammer-on dolly method to finish panel to original contour.	___	___	___	___
(**CAUTION:** *Do not use extreme force if the metal resists. Re-analyze the damage. A different technique may be necessary. Too much force will stretch or work harden the metal.)*				
Average of above evaluations*	___	___	___	___

(*This average may be used as the evaluation for Competency G3 "Roughout panel.")

UNIT I

JOB SHEET #3, LESSON TWO

USE PULL RODS TO ROUGHOUT A PANEL

Equipment:

Pull rod set
1/4 inch drill
1/8 inch drill bit
Straight edge
Eye protection

Procedure: **Evaluation:** 3 2 1 N

1. Put on eye protection and analyze where holes should be drilled. ___ ___ ___ ___

   (NOTE: If a lot of pressure is required, or the dent is large, several rods may be used at one time.)

2. Drill 1/8" holes along the deepest part of dent or crease. ___ ___ ___ ___

3. Insert pick end of pull rod(s) into the hole(s) at the shallowest point. ___ ___ ___ ___

4. Apply outward pressure until metal reaches original contour. ___ ___ ___ ___

5. While raising the dent with the pull rod, relieve the pressure around the edge with an appropriate body hammer. ___ ___ ___ ___

6. Continue this process until you have worked across the entire dent. ___ ___ ___ ___

   (NOTE: Continually check work with the straight edge.)

7. If high or low areas remain, repeat procedure until desired contour is obtained. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average may be used as the evaluation for Competency G3 "Roughout panel.")

UNIT I

JOB SHEET #4, LESSON TWO

USE PRY BARS TO ROUGHOUT A PANEL

(NOTE: If the panel is inaccessible for use of the hammer and dolly, a pry bar may be used to rough out the panel.)

Equipment:

Assortment of pry bars
1/4 inch drill
Proper drill bit
Proper body hammers
Straight edge
Eye protection

Procedure:	**Evaluation:** 3	2	1	N
1. Drill or punch holes through interior supports and structures.	___	___	___	___
(NOTE: Sometimes factory manufactured holes, such as drain holes, can be used.)				
2. Insert prying tool inside through access hole, and align the end of the tool with the area to be raised.	___	___	___	___
(NOTE: Use same procedure as pull rod; start at shallowest end first.)				
3. Apply light pressure to determine your location. Raise the metal by moving to new locations working from the outermost parts of the dent to the center.	___	___	___	___
(CAUTION: *Do not apply too much pressure as this tends to stretch the metal.)*				
4. While the metal is raised to the desired level, use the finishing hammer to relieve stress around the damaged area.	___	___	___	___
5. Use the straight edge to check your work and continue working with pry bars until desired contour is reached.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average may be used as the evaluation for Competency G3 "Roughout panel.")

UNIT I

JOB SHEET #5, LESSON TWO

USE A HYDRAULIC BODY JACK TO ROUGHOUT A PANEL

Equipment:

Hydraulic power jack set
Appropriate body hammers
Appropriate dolly
Combination wrench
Other hand tools, as needed
Trim panel tool
Door handle removal tool
Straight edge
Steel tape
Eye protection

(NOTE: This job sheet will cover the procedure for repairing a door, using the power jack to stretch the door back to its original contour.)

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
1. Remove the door from the vehicle. *(NOTE: If bolted on, remove the bolts - if welded on hinges, remove center pin.)*	___	___	___	___
2. Remove all accessories that could be damaged by the repair process (such as mirror, moldings, and interior trim).	___	___	___	___
3. Analyze damage and select the point which is the deepest.	___	___	___	___
4. Select hydraulic jack attachments to the correct length of the door.	___	___	___	___
5. Attach door clamps to the jack and the door.	___	___	___	___
6. Apply pressure slowly, allowing the damage to work its way out gradually.	___	___	___	___
7. Release pressure and check length with steel tape.	___	___	___	___
8. Use hammer and dolly techniques to return panel to its proper contour.	___	___	___	___
9. Remove hydraulic equipment from door.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average may be used as the evaluation for Competency G3 "Roughout panel.")

UNIT I

JOB SHEET #6, LESSON TWO

USE WELD-ON STUD GUN TO REPAIR SHEET METAL

Equipment:

Weld-on stud gun
Weld-on studs
Grinder
Appropriate grinding disk
Slide hammer
Eye protection (including full-face shield for grinder operation)
Heavy leather gloves

Procedure: **Evaluation:** 3 2 1 N

1. Examine damage, analyze, and determine needed location of weld-on stud(s). ___ ___ ___ ___
2. Put on safety glasses and clean surface with soap and water, then with wax and grease compound. Rinse thoroughly. ___ ___ ___ ___
3. Use grinder to remove paint from surface where studs will be welded. ___ ___ ___ ___
4. Select stud of appropriate size and prepare surface, following stud gun manufacturer's recommendations. ___ ___ ___ ___
5. Position stud and stud gun and weld following stud gun manufacturer's' recommendations. ___ ___ ___ ___
6. Using slide hammer and appropriate technique pull panel into approximate contour. ___ ___ ___ ___
7. Using side cutters, cut off weld-on studs, then use grinder to grind off remainder off stud weld area. ___ ___ ___ ___

(NOTE: The hammer and dolly method will usually be required to finish the panel at this point.)

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for Competency G9 "Use weld-on stud gun to repair sheet metal.")

UNIT I

JOB SHEET #7, LESSON TWO

HEAT SHRINK METAL

Equipment:

Grinder
Oxyacetylene torch
Correct sized welding tip
Correct dolly or spoon
Correct body hammer
Pail of water and sponge or rag
Heavy gloves
Welding goggles
Appropriate clothing

Procedure:

Evaluation:
3 2 1 N

1. Assemble all equipment, select correct sized welding tip, and put on safety equipment. ____ ____ ____ ____

   (NOTE: Select the correct sized tip for the gauge or sheet metal.)

2. Adjust torch to neutral frame. ____ ____ ____ ____

3. Hold inner cone of frame 1/2 inch from surface and heat a small area about the size of a dime until it is a dark cherry red. DO NOT OVERHEAT. ____ ____ ____ ____

4. Turn off and put aside torch as soon as metal reaches dark cherry red. Using a body hammer and dolly, drive the center of the spot down using the hammer-off-dolly method. ____ ____ ____ ____

   (NOTE: Hammer blows are placed directly on the ridge with a sloping or sliding motion toward the center of the heated area.)

5. Using the hammer-on-dolly method, drive the metal down around the heated area before the color turns black, working toward the heated area. ____ ____ ____ ____

Procedure:

Evaluation:
3 2 1 N

6. As soon as the metal cools to the point that the color leaves, quench the area with water. This should shrink out the remaining bulge.
___ ___ ___ ___

   (CAUTION: *Quenching the metal when it is too hot will result in the metal crystallizing and becoming hard and unworkable. In some cases the metal could even crack.)*

7. Continue the process on the next spot(s) to be shrunk.
___ ___ ___ ___

   (CAUTION: *Do not shrink another spot in the same area until the last one has completely cooled.)*

Average of above evaluations*
___ ___ ___ ___

(*This average is the evaluation for Competency G4 "Shrink panel.")

MODULE: PANEL REPAIRS

UNIT I TEST: SHEET METAL REPAIR

I. Match the correct definition in the left column with the correct term in the right column.

_____1. The ability of metal to be stretched without breaking

_____2. Collision damage which results to panels or areas of panels which have been forced to change shape due to the pressure resulting from direct damage.

_____3. Body repair stage in which damaged panels are aligned and reshaped to proper dimensions.

_____4. Point to which metal can be bent and still return to its original shape.

_____5. Compression of metal; opposite of stretch

_____6. Damage which is the direct result of the collision force at the point of impact and in the immediately surrounding area.

_____7. Change of granular structure of metal by bending or forming

_____8. Swelling and thinning of metal due to improper hammer and dolly technique; can result from bending and pulling.

_____9. The ability of metal to be compressed without breaking.

_____10. Bending or pivot point from which two areas of relatively undamaged metal have moved or shifted.

_____11. An area of metal which has been stretched such that it will "pop" in and out.

_____12. An area of damage where metal on each side of a pivot point is pulled together and forms a crease.

_____13. The point at which metal will stop flowing under pressure and will break.

A. Work hardening

B. Hinge buckle

C. Upset

D. Ductility

E. Plasticity

AB. Yield point

AC. Direct damage

AD. Indirect damage

AE. Roughout

BC. Roll Buckle

BD. Stretch

BE. Oil can

CD. Elastic limit

CE. Malleability

II. Mark a T on the answer sheet if the statement is true and an F is the statement is false.

______14. Hammer-on dolly method is when the hammer is placed directly above the dolly.

______15. Pull tabs is a roughout process where you drill a 1/8" hole into the sheet metal and place a tool into it, and apply pressure to remove the dent.

______16. Work hardening is a process where heat is applied to metal to make it stronger.

______17. To keep the work of straightening to a minimum, the damage must be removed in the reverse order in which it was created.

______18. When using a hammer to roughout a dent, firm hard blows are almost always necessary to move the metal.

______19. Indirect damage is caused by direct damage.

______20. To straighten sheet metal a flat dolly will do the best job.

______21. When using a grinder, the cross-cut method is moving the grinder up and down allowing about 1 1/2" of the disc to cut a pattern into the panel.

______22. In assessing the damage, the point of impact and the direction of impact must be assessed because the damage is generally removed in the reverse sequence in which it occurred.

______23. When you quench metal in heat shrinking you stop the metal from shrinking.

______24. Spring hammering is a technique where a coil spring is placed down on a high ridge and the spring is hammered on, thus preventing direct damage from hammer blows.

______25. In using the stud-gun, studs are welding onto damaged panels at the needed locations.

______26. The disadvantages of the stud-gun are that there is more chance of damaging the panel and the studs must be ground off.

______27. Heat shrinking works best on very small areas.

______28. When making metal panel repairs you must restore the panel's appearance, strength and function.

______29. Rolled buckles tend to end at some point in the crown with a sharp dent and the ridge above this dent is called the compression wrinkle.

______30. In analyzing how repairs are to be made on a panel or panels, you should remember the rule that the first damage which occurred in the accident is the first damage to be removed.

(NOTE: Completion of this unit test with a minimum score of ______ is necessary for the student to receive evaluations on Competencies G-1-G4 and G-9.)

ANSWERS TO UNIT I TEST

1. D
2. AD
3. AE
4. CD
5. C
6. AC
7. A
8. BD
9. CE
10. B
11. BE
12. BC
13. AB

14. T
15. F
16. F
17. T
18. F
19. T
20. F
21. F
22. F
23. T
24. F
25. T
26. F
27. T
28. T
29. F
30. F

MODULE: PANEL REPAIRS

UNIT II: PLASTIC BODY FILLER

UNIT OBJECTIVE

After completion of this unit the student should be able to mix, apply and finish body filler. Mastery will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

After completing this lesson this student should be able to:

Lesson 1:

I. Match terms to their correct definitions (Competencies G5 - G7, Unit II test)

II. Identify history and principles of body filler (Competencies G5 - G7, Unit II test)

III. Identify surface preparation procedures (Competencies G5 - G7, Unit II test)

IV. Identify principles of mixing filler (Competencies G5 - G7, Unit II test)

V. Identify principles of applying filler (Competencies G5 - G7, Unit II test)

VI. Identify principles of sanding filler (Competencies G5 - G7, Unit II test)

VII. Demonstrate the ability to:

   a. Clean exterior surface (Competency G5, Job Sheet #1)

   b. Prepare surface for body filler (Competency G5, Job Sheet #2)

   c. Apply plastic body filler (Competency G6, Job Sheet #3)

   d. Finish plastic body filler (Competency G7, Job Sheet #4)

MODULE: PANEL REPAIRS

UNIT II: PLASTIC BODY FILLER

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. References

D. Lesson plans

  1. Lesson 1: Plastic Filler

    a. Information outline

    b. Transparency masters

      TM#1 Crosscutting
      TM#2 Buffing

    c. Job sheets:

      JS#1: Prepare surface for body filler
      JS#2: Apply plastic body filler
      JS#3: Finish plastic body filler

E. Unit test

F. Answers to unit test

REFERENCES USED IN WRITING THIS UNIT

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2. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

3. Czapskie, George S., et. al. *Auto Body Repair.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1977.

4. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL. 1984.

5. Mitchell Information Services, Inc. *Body and Mechanical Parts Service & Repair, Domestic Cars, 1981-85.* Mitchell Information Services. San Diego, CA. 1985.

6. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

7. Toboldt, Bill. *Auto Body Repairing and Repainting.* The Goodheart-Willcox Co. Inc. South Holland, IL. 1982.

8. Walters, Terry, and Walker, Susan. *Automotive Body Repairer.* Curriculum & Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education. Stillwater, OK. 1986.

MODULE: PANEL REPAIRS

UNIT II: PLASTIC BODY FILLER

LESSON ONE: BODY FILLER

I. **Terms and definitions**

A. Air pocket – Air trapped in body filler when mixing due to improper stirring; as a result, affected plastic filler must be removed and refilled.

B. Base material – The resin mixture portion of the plastic filler to which a hardener is added.

C. Build-up – Amount of plastic filler necessary to build the surface being filled to the proper level.

D. Cheese Grater – Name given to the coarse, open-tooth file used by body technicians to rough file body filler.

E. Cure – To dry and harden.

F. Detergent – Cleansing agent (soap) which when mixed with water will cleanse oil and dirt from the automobile surface.

G. Hardener (catalyst) – Usually a pigmented cream which causes the plastic filler to harden; it also causes the color to change when it is properly mixed. (A catalyst is any material causing a chemical reaction. In this case the hardener causes the plastic filler to cure.)

H. Kneading – Mixing action to properly blend hardener with plastic filler.

I. Lightweight – Mixture of plastic and microscopic glass bubbles, which make it light and easy to work. Uses a cream hardener for curing.

J. Metal preparation – Step in which all impurities (slag, rust, dirt, protective coatings) are removed from panel surface before body filler is used.

K. Pin holes – Small holes in applied body filler due to improper mixing, too much hardener, or excessive heat from grinding the filler. If pin holes develop the plastic filler must be removed and replaced.

L. Plastic filler – A polyester resin to which various fibers and other materials have been added; used to fill dents in automotive body sheet metal.

M. Wax and grease remover – A solution for removing wax, grease, oil, and undercoating from automobile panels before body repair work has begun.

II. **History and principles of plastic body filler**

A. History

1. Plastic body filler was designed to replace body soldering in metal panel repairs. Soldering is still being used (sparingly) to repair some panel damage.

2. Problems with solder

    - a. Requires a source of heat (oxyacetylene torch) to apply it
    - b. Is very expensive
    - c. Contains 60-80% lead which could result in lead poisoning

  3. Advantages of plastic filler
    - a. Low in cost
    - b. Easy to apply
    - c. Adheres to clean base metal and is long- lasting
    - d. Requires no heat

B. Uses for plastic filler

  1. Used to finish panels to original contour following roughing out procedures
  2. Used to fill seams left by welding, brazing or riveting operations

C. Composition of plastic body filler

  1. Plastic body filler has a variety of compositions
    - a. Basic plastic filler (base material) has traditionally been composed of 50 percent powdered talc (magnesium silicate) and 50 percent polyester resin.
    - b. New technologies are radically changing the compostion of plastic filler, with new materials taking the place of talc, which tends to absorb moisture.
    - c. Metal- or fiberglass-plastic fillers have particles of fiberglass, aluminum or steel instead of talc.
    - d. One filler known as "Lightweight" is composed of polyester resin and microscopic glass spheres.
    - e. Fillers come in cans or dispensers of various sizes and the filler has a thick consistency.
  2. All plastic fillers require a hardener (catalyst)
    - a. The catalyst is mixed with the base material and causes a chemical reaction which begins to harden the plastic in a very short time. During this chemical reaction, the plastic filler releases heat.

      (NOTE: The working time for plastic filler will vary according the type of filler, the temperature, and the amount of hardener. Generally, a properly mixed filler applied at room temperature will become unworkable after approximately 10 minutes and will cure after approximately 30 minutes).
    - b. Only a small amount of hardener is added in proportion to the filler.
    - c. Hardener usually comes in a tube and is more of a liquid than the filler.

D. Limitations of plastic fillers

1. Cannot be used to fill out the edge of a panel as moisture can work under the edge and the plastic filler fall off. Edges are also susceptible to chipping. Use lead or other approved method for filling imperfections in the edges of panels.

2. Cannot safely be used to fill depressions deeper than 1/4 inch. Thicker application can crack or break off.

3. Metal must be completely ready for filling prior to application because once plastic filler is applied, further bending and shaping of the metal cannot be done without damaging the plastic.

4. Plastic filler will not flex and cannot be used on flexible panels.

5. Plastic filler cannot be used to fill over large holes or tears. Small holes, such as drill holes, can often be filled with plastic.

6. Cannot cover up rust spots.

   (NOTE: Rust spots can sometimes be repaired with foam filler, a plastic-filler type material that expands after being mixed. However, in any type of rust repair, ALL the rust must be removed before repair is made.)

III. Surface preparation

A. Proper surface preparation is critical for plastic filler applications.

1. The surface temperature must be above 50 degrees.

2. Normal room temperature is recommended.

3. The surface temperature should not be extremely hot, and the filler should not be applied in direct sunlight.

B. The roughed-out surface must be close enough to proper contour that plastic filler can be applied to a thickness of no greater than 1/4 inch.

C. Panel must first be washed with detergent and water.

D. Area to be filled must then be thoroughly cleaned with wax-and-grease remover.

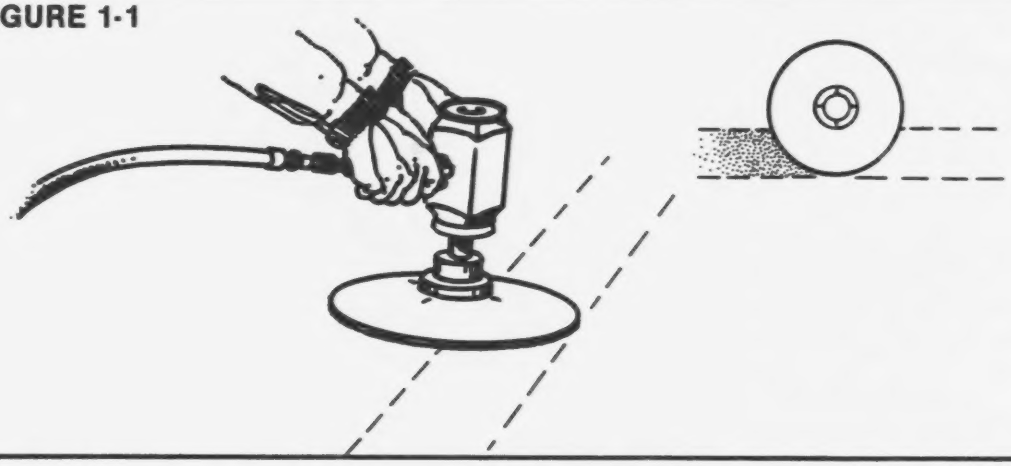
E. Surface should again be cleaned with a prefinishing cleaner or approved solvent.

F. All paint, slag and other impurities must be removed by sanding with a disk sander using proper technique.

G. Proper technique for using disk sander

1. Disk should be tipped at slight angle to the surface, such that area of the disk from the center hub to the edge is in equal contact with the surface being sanded. The grinder should be at approximatley a 5 degree angle. (FIG. 1-1)

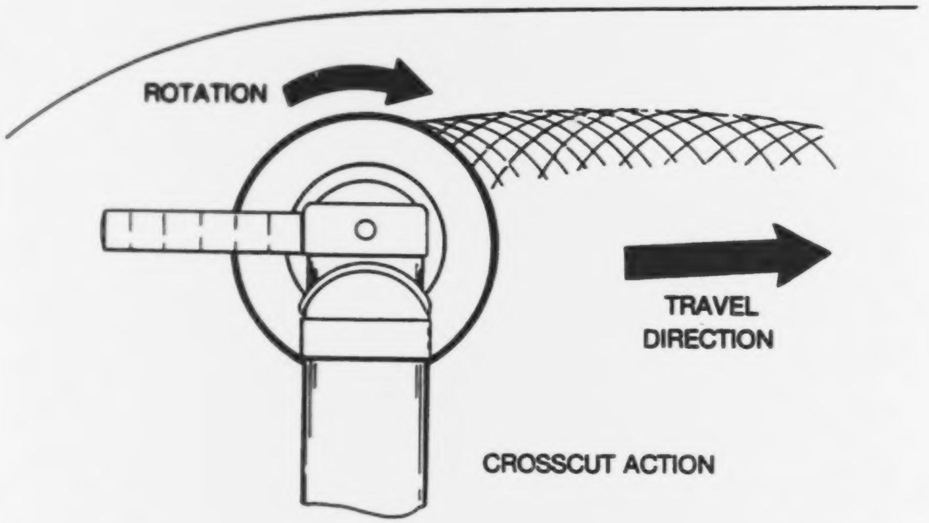
FIGURE 1-1



2. Just enough pressure should be applied to bring the disk in proper contact with the surface. Too much pressure will bend the disk and the resulting pressure will burn the metal.
3. The sander should be moved back and forth in long, sweeping strokes that overlap.
4. Do not move sander in circles.
5. Do not hold sander in one spot or the metal will be burned.

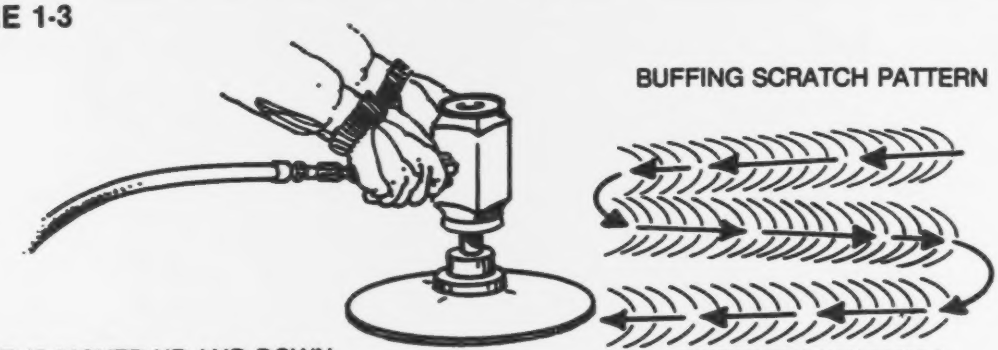
6. Sander should first be moved from side-to-side, horizontally (cross-cut method). The cross-cut method helps determine high and low spots. (FIG. 1-2)

FIGURE 1-2


ROTATION
TRAVEL DIRECTION
CROSSCUT ACTION

7. After area to be filled has been thoroughly sanded with cross-cut method, sand area with up-and-down motions (buffing method). The buffing method helps reduce the ribs left by the cross-cut method. (FIG. 1-3)

FIGURE 1-3


BUFFING SCRATCH PATTERN
GRINDER IS MOVED UP AND DOWN
DIRECTION OF TRAVEL

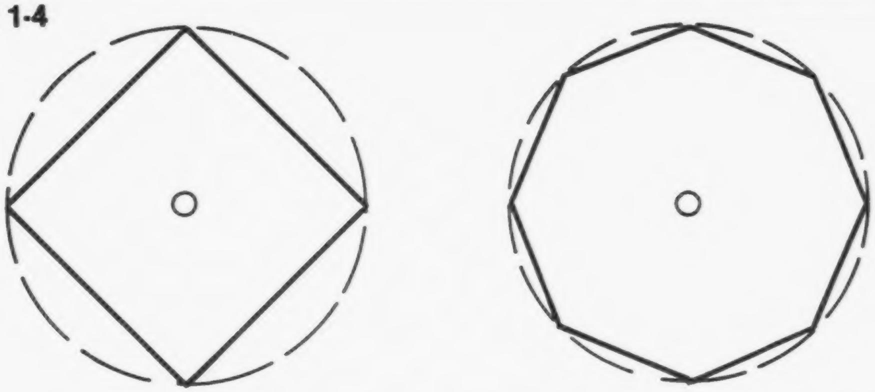
8. For a small area use a 7" grinding disk. For a large area use a 9" grinding disk.

9. Grit size recommendations leave some room for personal preference. Most technicians use a 16- or 24-grit open-coat disk. The coarser the grit, the deeper the scratches. Plastic filler needs a roughed surface for proper adhesion.

   (**CAUTION:** *Be sure not to grind beyond the area to receive filler or this will cause additional work in preparing the surface for refinishing.)*

H. For small dents or creases that cannot be reached with a round disk, use an octagonal or square disk. (FIG. 1-4)

FIGURE 1-4



I. For sanding reverse curves, use an abrasive tube of appropriate size and grit.

IV. **Mixing filler**

(**CAUTION:** *Wear rubber gloves when mixing and applying plastic filler. The hardener can be absorbed through the skin and can cause liver damage.)*

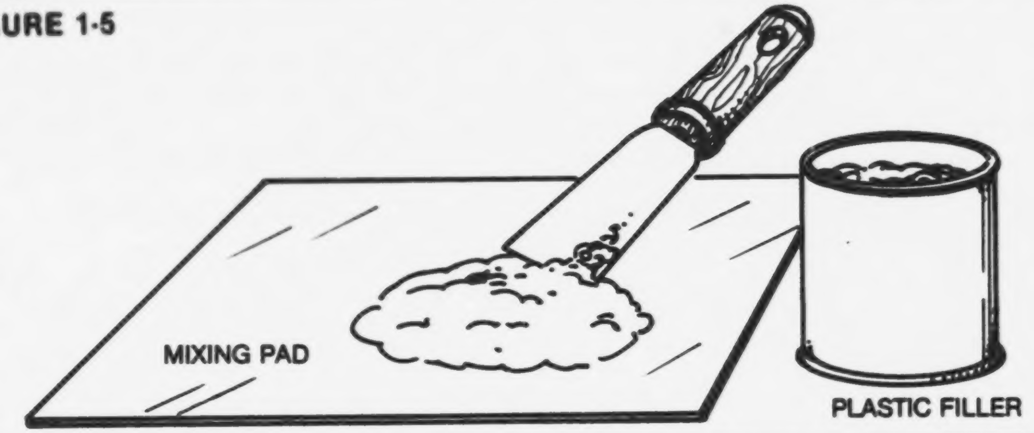
A. After properly preparing surface, check to make sure that surface is free of grinding dust and moisture. If needed, wipe surface lightly with a clean, dry, lint-free rag.

B. Read instructions on plastic filler. Each type and brand of filler has somewhat different directions. Follow procedures on label where they differ from the general procedures outlined below.

C. Guidelines for working time .

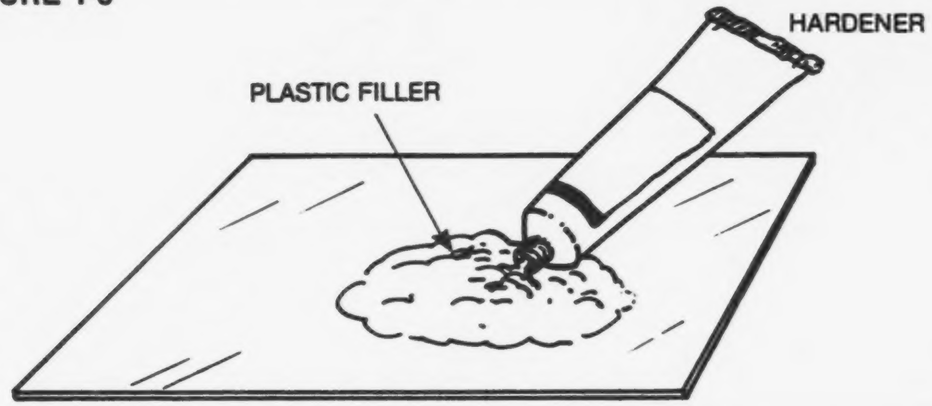
1. Mix and apply only the amount of filler you can apply in the time you have before it sets up. A golf-ball sized lump of base material is about right when you are first learning the procedure. (FIG. 1-5)

FIGURE 1-5



2. Use slightly less hardener than recommended when first learning the procedure. This will allow more time to work with the material before it sets up. (FIG. 1-6)

FIGURE 1-6



3. Remember that properly mixed material has a working time about 10 minutes and completely sets up after 30 minutes.

4. On a hot day the filler will cure faster, so less hardener should be used. On a cold day the filler will cure slower so more hardener should be used. Check label for recommendations.

5. Do not return any mixed material back to the can of base material. It will contaminate the remaining base material.

D. General procedure for mixing filler

1. Follow mixing directions on label. Generally a golf ball-sized lump will require a one- or two-inch ribbon of hardener.

2. Mix the material on a smooth, clean, non-porous surface, such as a clean section of safety glass with no sharp edges, a clean piece of sheet metal, or a section of smooth, hard plastic. (DO NOT use cardboard.)

3. Use a mixing paddle to place a golf-ball sized lump of the base material on the mixing surface.

4. Place the proper amount of hardener on top of the base material.

   (NOTE: The hardener is pigmented and the base material is white or gray. The different colors help show when the two have been properly mixed.)

5. In mixing the two together, be careful not to mix the material too swiftly. Do not "whip" the material or air bubbles will form.

6. Use a clean wide-bladed putty knife and mix the ingredients by scooping the mixture up from the bottom and turning the putty knife over and pressing down on the mixture, kneading the two materials together.

7. Knead until the material is smooth and creamy and uniform in color.

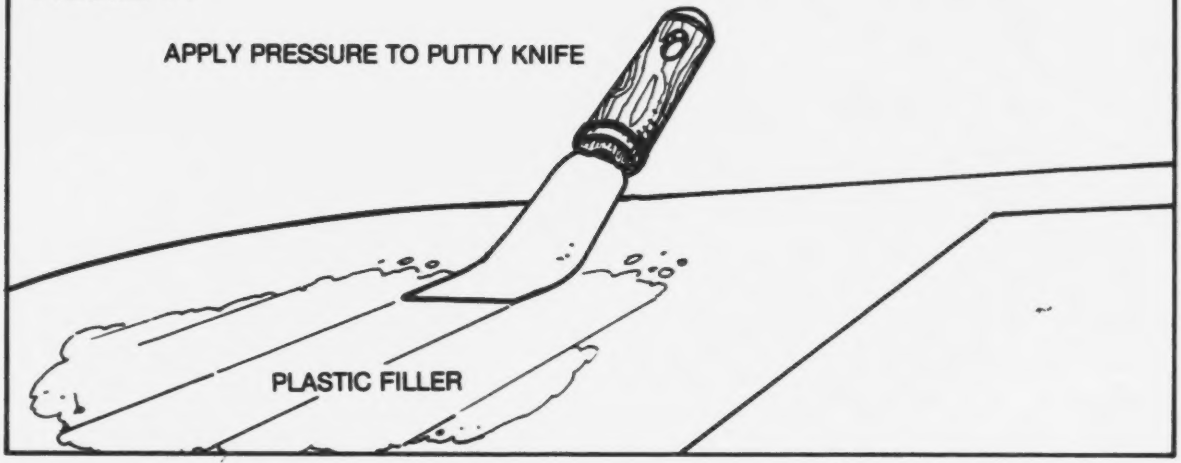
8. Remember to thoroughly clean the putty knife and mixing surface after each mixing procedure. An uncleaned board will produce crumbs in your next mix that will prevent you from doing a good job.

V. **Guidelines for application**

A. Apply filler immediately.

B. Use a squeegee, a wide-bladed putty knife or a plastic spreader. (FIG. 1-7)

FIGURE 1-7


APPLY PRESSURE TO PUTTY KNIFE
PLASTIC FILLER

C. Apply a thin coat on area to be filled. If the surface is close to proper contour, one coat may be sufficient.

(NOTE: When the filler is hard enough to resist scratching with your fingernail, it can be sanded or filed.)

D. Allow first coat to cure, then use an air file to file the surface, providing a roughed area for the second coat.

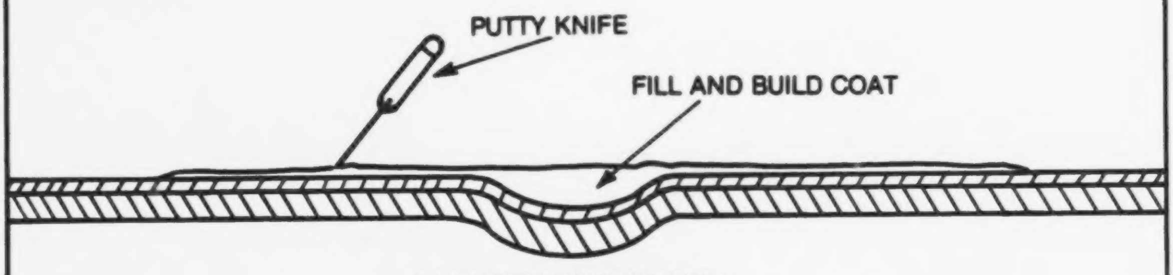
(NOTE: Plastic filler coats must cure and must be air filed or otherwise roughed up for adhesion before the next plastic filler coat is applied. The surface must be clean and dust free as well. Plastic filler must cure in thin coats because the curing process involves the release of a gas produced by the chemical reaction. If the filler is too thick, this gas will become trapped, causing air pockets. Using too much hardener can cause the filler to set up before this gas can escape.)

E. Apply a slightly thicker coat next (but still thin), with even strokes in one direction only, using moderate force. Allow to cure, then rough up if another coat is be applied.

F. Apply additional thin coats, if needed, until plastic filler achieves the proper build up -- higher than the contour of the panel. (FIG. 1-8)

(NOTE: The key to plastic filling is to build the plastic up such that there is an excess of material at all points in the repair area. This excess is then grated, ground and/or sanded off until the proper contour remains.)

FIGURE 1-8



FILL ENTIRE DAMAGE AREA

F. If there is a crease or low spot, allow the first built up layer of material to set up, then rough the surface and apply additional layers of material directly to the low spot. (All such layers together still must not exceed 1/4 inch.)

VI. **Guidelines for sanding filler**

(CAUTION: Always wear a particle mask when sanding or grinding plastic body filler. The dust particles from the sanding and grinding operations are harmful if inhaled.)

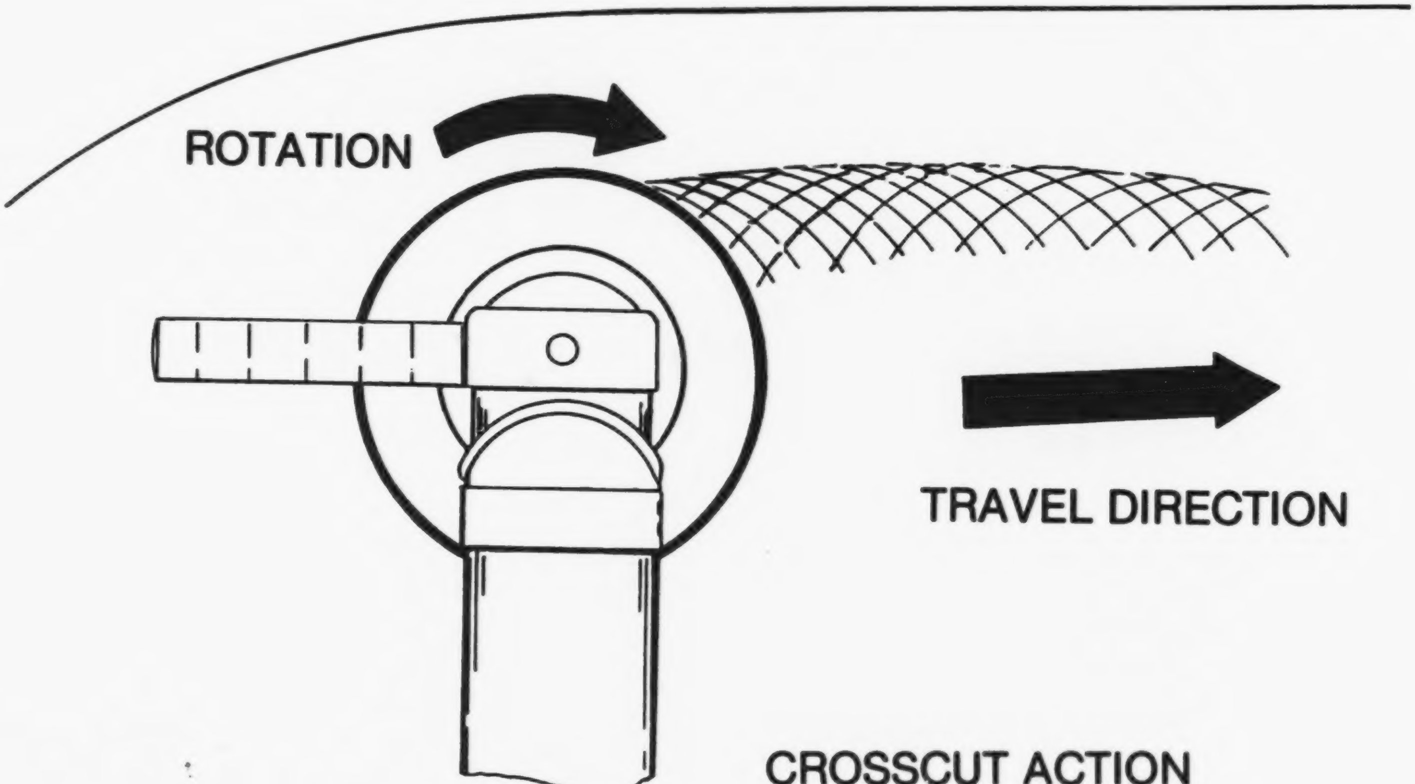
A. A body-filler shaping blade (cheese grater) may be used to shape the filler before it is fully cured.

B. The cheese grater is flexible and can bring the surface down to approxiate contour, saving sanding time.

C. When sanding, use a rotary sander with a 50-grit disk as the first step, then change to an 80-grit disk for final sanding. *(Note: DO NOT use any paper finer than 80-grit for plastic filler sanding.)*

D. Once the surface is at proper contour, free from high or low spots, and has been sanded with 80-grit paper, the panel is ready to be prepared for painting.

Crosscutting (Discing)

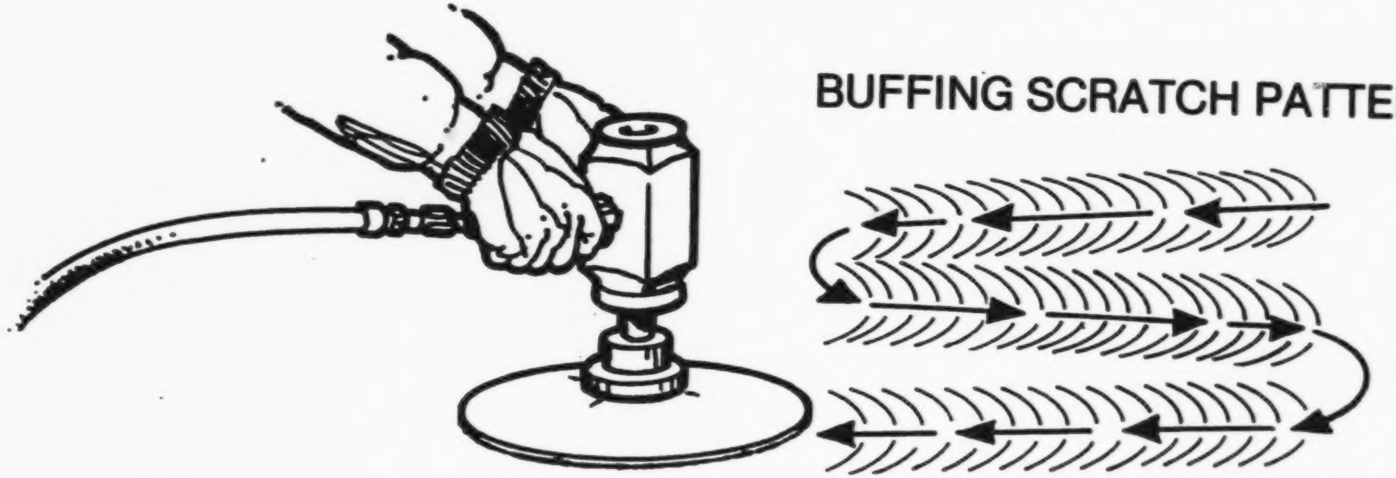


ROTATION

TRAVEL DIRECTION

CROSSCUT ACTION

Buffing


BUFFING SCRATCH PATTERN
DIRECTION OF TRAVEL
GRINDER IS MOVED UP AND DOWN

UNIT II

JOB SHEET #1, LESSON ONE

CLEAN THE EXTERIOR SURFACE

Equipment:

Clean rags and towels
Degreasing solvent
Bucket and sponge
Detergent
Chamois

Procedure:	**Evaluation:** 3	2	1	N
1. Wash panel. *(NOTE: Using the detergent with water in a bucket, sponge off panel using a firm motion to clean all dirt from the panel.)*	___	___	___	___
2. Chamois panel dry.	___	___	___	___
3. Degrease panel.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency H4 "Clean the exterior surface.")

UNIT II

JOB SHEET #2, LESSON ONE

PREPARE SURFACE FOR BODY FILLER

Equipment:

Portable body grinder
24-grit disc
Disc trimmer
Drill motor
Wire brush for drill motor
Masking tape
Safety glasses or face shield

Procedure:

		Evaluation:			
		3	**2**	**1**	**N**
1.	Put on eye protection, remove moldings, if present, and mask any adjacent panels.	___	___	___	___
2.	Attach a 16- or 24-grit disc to a portable grinder, either air or electric. (**CAUTION:** *Check grinding disc manufacturer's recommendations to be sure the grinder being used is of the correct RPM.)*	___	___	___	___
3.	Grind the panel using cross-cut method.	___	___	___	___
4.	Grind the panel using the buffing method.	___	___	___	___
5.	If paint or other foreign material is still present in low spots grind with hexagon or square shape disc.	___	___	___	___
6.	If surface rust or other materials still remain, wire brush panel with rotary wire brush on drill.	___	___	___	___
	Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency H7 "Prepare surface for body filler.")

UNIT II

JOB SHEET #3, LESSON ONE

MIX AND APPLY BODY FILLER

Equipment:

Plastic body filler
Hardener
Wide putty knife or plastic spreader
Plastic, metal or glass mixing surface

Procedure:

		Evaluation: 3	2	1	N
1.	Read the instructions on filler and hardener containers and put on rubber gloves.	___	___	___	___
2.	Estimate the amount of filler required using the size of a golf ball as a guide.	___	___	___	___
3.	Apply the estimated amount of filler onto the mixing surface. Then apply the hardener to the filler following directions on labels.	___	___	___	___
4.	Mix the ingredients thoroughly by using a wide-bladed putty knife by scooping from the bottom and turning the putty knife over to press down on the mixture.	___	___	___	___
5.	Scoop a small amount of filler onto your putty knife and apply a thin coat over the area to be filled, applying firm inward pressure. *(NOTE: The inward pressure will allow the filler to move into the scratches left by the grinder, ensuring a grip.)*	___	___	___	___
6.	Apply the necessary amount of filler, one layer at a time, to build the filler a little higher than the original contour.	___	___	___	___
7.	Clean your putty knife and mixing board thoroughly with a solvent (such as lacquer thinner) after each use.	___	___	___	___
	Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency H4 "Apply body filler.")

UNIT II

JOB SHEET #4, LESSON ONE

FINISH BODY FILLER

Equipment:

Cheese grader
Grinder
24-grit disc, 36-grit disc, 40-grit disc
Finishing sander
Hand sander

Procedure:

Evaluation:
3 2 1 N

1. After filler has cured, put on particle mask and remove surplus material using one of the two procedures below. ____ ____ ____ ____

    a. Using a cheese grater, applying long strokes and changing directions to prevent waves.

    b. Using a 7" or 9" grinding disc and the cross-cut method and then the buffing method.

2. If low spots remain in the filler, mix and apply more material and repeat step 1. ____ ____ ____ ____

3. Select the finishing sander to be used and attach a 36-grit or 40-grit piece of sandpaper to the face of the sander. ____ ____ ____ ____

4. Place sander flat on the surface and sand in straight lines, changing directions to prevent waves in the filler. ____ ____ ____ ____

    (NOTE: Sand with the contour. If up and down,change directions 30-45 degrees in both directions occasionally.)

5. Sand the surface until you have reached the proper contour. ____ ____ ____ ____

6. Replace sandpaper on the sander with 80-grit then sand until the scratches left by 36- or 40-grit become smooth. ____ ____ ____ ____

7. Sand broken edges surrounding the repaired surface, using proper sander and disc. ____ ____ ____ ____

Procedure:	**Evaluation:** 3	2	1	N
8. Check the repaired area for deep scratches, pits, shape and original contour. If not satisfactory, reapply and finish filler as needed.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency H9 "Finish body filler.")

MODULE: PANEL REPAIRS

UNIT II: PLASTIC BODY FILLER

UNIT II TEST

I. Match the following definitions in the right column with their corresponding terms in the left column.

_____1. Tiny spaces in cured filler caused by improper mixing and too much hardener.

_____2. Thin layer of filler skimmed over the damaged area.

_____3. Pigmented cream or liquid curing agent used in plastic and fiberglass resins.

_____4. Any material used to level a damaged area.

_____5. Air trapped in filler because of improper stirring when mixing.

_____6. Coarse open-toothed file used to shape plastic filler.

_____7. To dry and harden.

_____8. Mixing technique used to properly blend base material and catalyst.

_____9. Step in which all impurities (paint, slag, rust, dirt, protective coverings) are removed from panel surface before body filler is used.

A. Cure

B. First coat

C. Filler

D. Cheese grater

E. Surface preparation

AB. Pin holes

AC. Hardener

AD. Air pockets

AE. Plastic coat

BC. Knead

II. Select the best answer from the choices listed.

_____10. Plastic body filler should never be applied: (a) in very thin layers, (b) in very thick layers, (c) both a and b, (d) neither a nor b.

_____11. Plastic body filler should never be applied in a total thickness greater than: (a) 1/16 inch, (b) 1/8 inch, (c) 1/4 inch, (d) 1/2 inch, (e) 1 inch.

_____12. All of the following tools may be used in mixing with plastic body filler except: (a) Spatula, (b) squeegee, (c) sanding block, (d) wooden paddles, (e) rotary sander.

_____13. The recommended working time for plastic filler is approximately: (a) 5 minutes, (b) 10 minutes, (c) 20 minutes, (d) 30 minutes, (e) 40 minutes.

_____14. You cannot use plastic filler to fill out the edge of a panel because: (a) It might chip, (b) the filler might fall out, (c) moisture might work under the edge, (d) all of the above, (e) none of the above

III. Mark a T on the test or answer sheet if the statement is true and an F if the statement is false.

_____15. On your first job, using more rather than less hardener will give you more time to work before curing takes place.

_____16. Read and follow all instruction labels on filler and hardener containers.

_____17. Never mix more plastic filler than you can apply in one hour.

_____18. Never return mixed plastic to the container as it will contaminate the base material and cause it to set up.

_____19. Mix ingredients on a clean sheet of cardboard.

_____20. Mix until base material is uniformly streaked throughout.

_____21. Use a wide-bladed putty knife to knead the two ingredients by scooping from bottom and turning putty knife over to press down on mixture.

_____22. Whip the ingredients to create air bubbles that will strengthen the material later.

_____23. Always thoroughly clean plastic spreader and mixing sheet in solvent after each use.

_____24. On a hot day plastic filler will cure faster, so more hardener should be used.

_____25. If the plastic filler gets hard enough to resist scratching with your fingernail, it means you used too much hardener.

(NOTE: Completion of this unit test with a minimum score of _________ is necessary for the student to receive an evaluation on the Job Sheets in Unit Two.)

ANSWERS TO UNIT II TEST

1. AB
2. B
3. AC
4. C
5. AD
6. D
7. A
8. BC
9. E

10. B
11. C
12. C
13. B
14. D

15. F
16. T
17. F
18. T
19. F
20. F
21. T
22. F
23. T
24. F
25. F

MODULE: PANEL REPAIRS

UNIT III: PANEL REPLACEMENT

UNIT OBJECTIVE

After completion of this unit, the student should be able to replace vehicle panels. Mastery will be evidenced through demonstration and by scoring __________ percent on the unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit the student should be able to:

Lesson 1:

I. Match basic terms with their definitions or illustrations. (Competencies J1-J6, Unit III test.)

II. Identify basic replacement procedures and cautions (Competencies J1-J6, Unit III test.)

III. Demonstrate the ability to:

- a. Remove and replace quarter panel (Competency J1, Job Sheet #1)
- b. Remove and replace bonded door panels (Competency J6, Job Sheet #2)
- c. Remove and replace door intrusion barrier (Competency J5, Job Sheet #3)
- d. Remove and replace rocker panel (Competency J2, Job Sheet #4)
- e. Section quarter panel (Competency J4, Job Sheet #5)

Lesson 2:

I. Match terms with their definitions (Competencies J1-J6, Unit III test.)

II. Identify types of panels often needing alignment (Competencies J1-J6, Unit III test.)

III. Identify alignment procedures. (Competencies J1-J6, Unit III test.)

IV. Demonstrate the ability to:

- a. Remove and replace hood (Competency J3, Job Sheet #1)
- b. Remove and replace fender (Competency J3, Job Sheet #2)
- c. Remove and replace door (Competency J3, Job Sheet #3)
- d. Remove and replace a deck lid (Competency J3, Job Sheet #4)

MODULE: PANEL REPAIR AND REPLACEMENT

UNIT III: PANEL REPLACEMENT

CONTENTS OF THIS UNIT

A. Objective sheet

B. Notes to the instructor

C. References

D. Lesson plans

1. Lesson 1: Panel Replacement

   a. Information outline

   b. Transparency masters

   TM#1: Rocker panel assembly
   TM#2: Removing hem flange of door

   c. Job sheets:

   JS#1: Remove and replace quarter panel
   JS#2: Remove and replace bonded door panels
   JS#3: Remove and replace door intrusion barrier
   JS#4: Remove and replace rocker panel
   JS#5: Section quarter panel

2. Lesson 2: Panel alignment

   a. Information outline

   b. Job sheets

   JS#1: Remove and replace hood
   JS#2: Remove and replace fender
   JS#3: Remove and replace door
   JS#4: Remove and replace deck lid

E. Unit test

F. Answers to unit test

NOTES TO THE INSTRUCTOR

A. In Lesson Two, any of the four job sheets may be used to evaluate Competency J3 "Remove and replace cosmetic panels, bolted on."

REFERENCES USED IN WRITING THIS UNIT

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5. Inter-Industry Conference on Auto Collision Repair. Unibody Auto Collision Repair Training Program. *Unibody Structural Sectioning and Use of Recycled Parts.* Inter-Industry Conference on Auto Collision Repair. Des Plains, IL. 1984.

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9. Toboldt, Bill. *Auto Body Repairing and Repainting.* The Goodheart-Willcox Co. Inc. South Holland, IL. 1982.

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MODULE: PANEL REPAIRS

UNIT III: PANEL REPLACEMENT

LESSON ONE: REPLACING PANELS

I. **Terms and definitions.**

A. Apron tower -- In unibody vehicles the panel which is attached to the front frame rail and inner shield and forms the attachment point for MacPherson struts.

B. Body rails -- The structural panels which extend from the floor panel forward and rearward and provide the attaching points for several inner panels.

C. Cosmetic panels/structural panels -- Vehicle panels which do not contribute significantly to the strength of the vehicle are called cosmetic panels and vehicle panels which *do* contribute significantly to the strength of the vehicle are called structural panels. For unibody vehicles the body rails, front and center pillars, rocker panels, trunk floor, floor panel, and firewall are considered primary structural panels and all the rest are usually considered cosmetic panels (even though they do contribute to the strength of the vehicle).

(NOTE: On frame body vehicles the designation of structural and non-structural panels is not usually made, since the frame provides the strength of the vehicle.)

D. Deck lid -- A moveable panel covering the trunk.

E. Door panel/door skin -- The inner and outer panel of the door together form the door panel. The exterior panel of the door, often replaced by itself, is called the door skin.

F. Fender -- The panel covering the front wheel on each side of the vehicle, and connected to the radiator support at the front and the front hinge pillar (A-pillar) at the rear.

G. Floor panel -- The panel which forms the floor of the passenger compartment.

H. Front hinge pillar (A-pillar) -- The lower portion of the A-pillar.

I. Hood -- A moveable panel covering the engine compartment.

J. Inner shield -- The panel which is attached to the front frame rail and forms the interior side wall of the engine compartment. It is welded to the frame rail and the fender is bolted to the inner shield.

K. Panel -- Any cosmetic or structural portion of the unibody vehicle which is welded or bolted to the unibody assembly.

L. Pillars -- The box section panels which support the roof panel and form the door and window openings. Windshield pillars/front hinge pillars are also called A-pillars, center pillars are also called B-pillars, and rear pillars, where present, are also called C-pillars.

M. Quarter panel -- The panel at each corner of the rear of the vehicle. The quarter panel may be a relatively small panel, such as in a four-door compact, or a very large panel, such as in a full-size, two-door vehicle.

N. Radiator support -- The panel which is bolted between the fenders at the front of the engine compartment which provides the attachment point for the radiator.

O. Rocker panel -- The panel located at the lower, outside edge of the passenger compartment and connected to the front hinge pillar at the front and the quarter panel at the rear.

P. Roof panel -- The panel covering the passenger compartment and connected to the pillars and quarter panel.

Q. Sectioning -- The act of cutting a panel in a location other than its factory seams.

R. Trunk floor -- The panel which forms the floor of the trunk.

II. Replacing panels

(NOTE: The discussion in this unit is directed toward unibody vehicles. Panel replacement procedures outlined are largely the same for frame-body vehicles, except that panel attachment methods will be different in some cases. Also, what follows is not a complete list of vehicle panels, but is an attempt to list those panels which are common to most vehicles and which are frequently replaced.)

A. When the damage to a panel reaches a certain level it becomes cheaper to replace the panel than to repair it.

B. Panels which are frequently replaced:

1. Quarter panels, inner and outer
2. Door panels, inner and outer
3. Fenders, inner and outer
4. Hoods
5. Decks
6. Radiator supports
7. Rear lower panels
8. Bumpers (see Unit VI)

C. Other major panels which can be replaced:

1. Pillars
2. Rocker panels
3. Roof panels, including header bars and side panels
4. Trunk floors
5. Body rails

D. Floor panels and cowl panels are hardly ever replaced, since damage severe enough to those panels to require replacing will almost always mean the vehicle cannot be economically repaired.

E. Some panels are often sectioned, rather than completely replaced. In sectioning panels the panel is cut at a location different from the factory joint(s).

(NOTE: This unit will deal with sectioning quarter panels only, which are considered cosmetic panels. The sectioning of pillars, rocker panels, and body rails, as well as trunk floors and floor panels is covered in the Module 7 unit dealing with unibody structural sectioning.)

F. Methods of attaching panels

1. Most panels on modern vehicles are welded together to form the unibody vehicle, with only a few panels bolted on.

2. Panels which are almost always bolted on include the fender panels and the radiator support.

3. Panels which are always bolted on include the hood and deck lid.

4. When replacing welded panels other than quarter panels they should be replaced only at factory seams or matching flanges. For sectioning welded panels other than quarter panels on unibody vehicles see the Frame Repair Module.

5. Whenever replacing more than one panel, always replace stationary panels first. The reason is that the moveable panels may be adjusted to align with the stationary panel, but not vice versa.

(NOTE: The only moveable panels are the doors, hood, deck and fenders.)

G. Tools and safety

1. Tools used for panel replacement

a. For replacing at factory spot welds, drilling out the spot welds is recommended.

b. After drilling spot welds, use an impact tool with chisel to separate the rest of the weld seam.

c. For sectioning stationary panels a pneumatic or electric disc grinder with proper cutting tool, or a metal saw, is recommended.

d. Avoid using an oxyacetylene torch, except to mildly heat any adhesives for removal.

2. Safety considerations in cutting metal

a. Always wear heavy gloves, safety glasses and a face shield when using grinders, metal saws or impact tools. When using grinders, wear heavy clothes with flaps over the shirt pockets.

b. Using a grinder or impact tool will cause sparks which can damage adjacent paint or glass. Always mask adjacent areas which need no repairs. (Even if areas need refinishing, mask to avoid additional damage.)

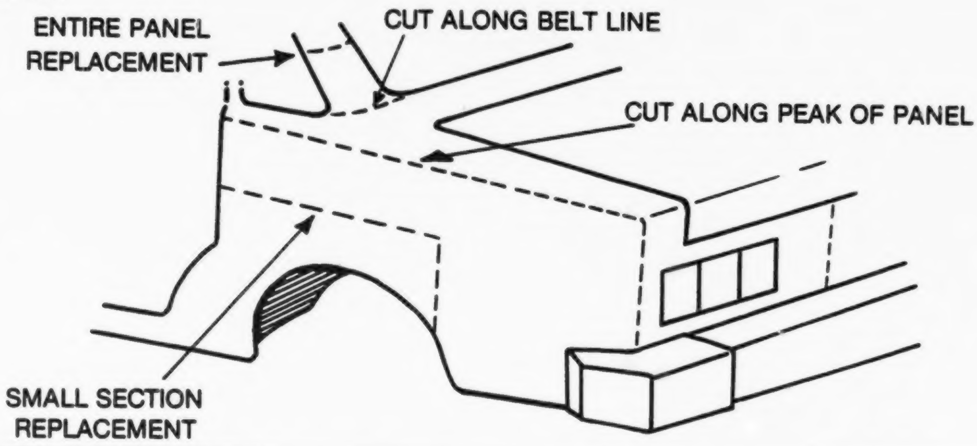
c. When working near fuel filler opening or fuel tank, always use special precautions. If using a metal saw or an impact tool the fuel filler cap can be secured tightly and the fuel filler opening can be covered with a wet rag. USE GOOD JUDGMENT IF YOU USE THIS METHOD. If you are using a disc grinder or oxyacetylene torch near the fuel filler opening or fuel tank ALWAYS remove the fuel tank first.

H. Quarter panel replacement

1. When supporting a vehicle for quarter panel repair, the weight should rest on the suspension or on jack stands in the torque box areas.

2. The complete quarter panel or any section of the quarter panel may be removed and replaced. (FIG. 1-1)

FIGURE 1-1



3. Often it is more economical to cut out and replace only the damaged portion of the panel.

4. When replacing a complete quarter panel, the rear window and rear side windows, along with some interior trim and some trunk trim, may have to be removed.

5. When replacing a quarter panel or a section of a quarter panel, correct measuring is extremely important. Check the dimensions of the cut properly. On of the first cut of the replacement panel, allow an extra length of metal which can be trimmed later.

6. Always check for damage to inner panels.

(NOTE: Inner panels are usually composed of several inner panels welded together. If seriously damaged, some of those panels may have to be replaced. Inner panels include the wheel house panel {inner and outer}, the rear shock tower, and the trunk floor extension.)

7. Clamp replacement panel into place to check alignment, then trim new panel, allowing two inches extra at top for new plug welds.

8. Apply corrosion protection recommended to back of replacement panel. If corrosion protection to inner panel is damaged, restore it.

9. Grind off paint from areas of old panel to be welded.

10. Use C-clamps and locking pliers to clamp section in place.

11. Tack weld, using MIG welder and appropriate welding rod, then remove clamps and check alignment.

12. Use weld-through primers in all welding operations.

13. Use plug weld with MIG welder to fasten overlap areas or to refasten at factory spot weld locations. On long seams, use stitch weld techniques.

14. Check alignment and finish welds.

15. Use disc grinder to smooth welds and prepare for body filler.

16. Use proper seam sealer on any seams.

17. Use body filler, sand and paint according to procedures outlined in Unit II and in Module 4, "Paint and Refinishing."

I. Door panel replacement

   1. If more than one door is damaged on same side of vehicle, repair the rear door first

   2. If damage is only to outer panel, door skin replacement is used.

   3. If there is serious damage to inner panel, entire door is usually replaced.

   4. Door skins are attached by both welding and bonding with adhesive. In the case of replacing a door skin bonded with adhesive, the procedure is the same as for a welded-on panel, except that the adhesive is applied to the crimp area, instead of being welded. (Follow adhesive manufacturer's recommendations for preparation and application.)

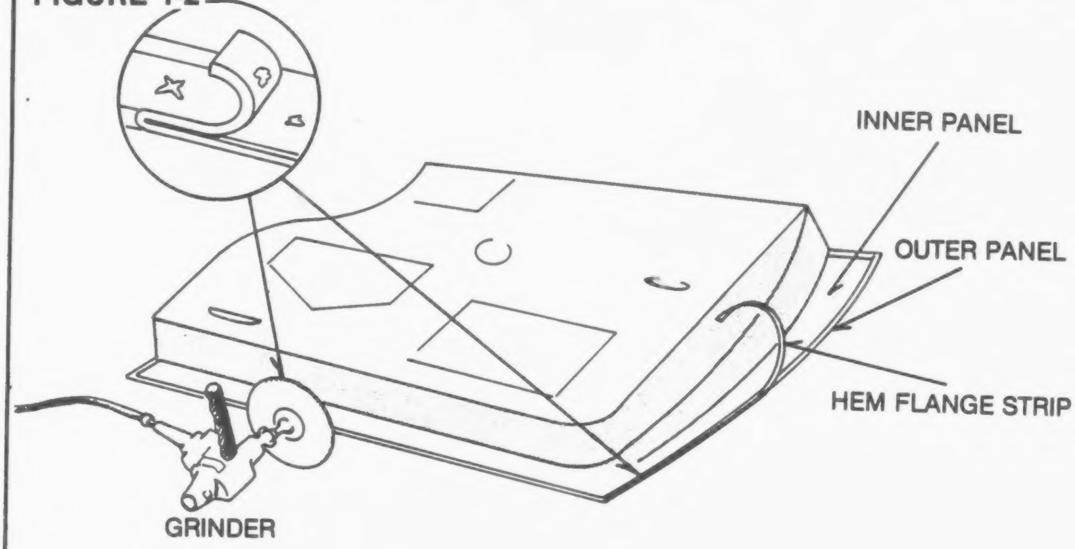
   5. Procedure for door skin removal

      a. Remove door from vehicle following service manual recommendations.

      b. Remove trim panel and all interior components, door lock assembly, and glass and window regulator to keep from damaging them. Refer to Exterior and Interior Trim, Module 5.

c. Grind outer flange attaching door skin to inner panel with grinder until crimped skin separates. (FIG. 1-2)

FIGURE 1-2



d. Drill out spot welds at top of door or use impact tool and chisel. Be careful not to damage inner panel.

e. Repair any damage to inner panel with a hammer and dolly. Restore any corrosion protection which was damaged.

f. Check alignment by placing replacement door skin over inner door panel. If alignment is good, then panels can be welded together.

g. Place door skin face down on bench. Place inner panel down onto door skin. With the ends of panel over outer edge of table, crimp flange of door skin over edge of inner panel. Use recommended tool. (If adhesive is used, it is applied before making the crimp.)

h. To avoid uneven strain, it is recommended that the bottom and the two sides of the door skin be crimped over the inner panel in an alternating procedure. (Make one crimp on left side, then one crimp on right, one crimp on bottom, then one crimp on left, etc.)

i. When crimp is completed, weld edge using stitch weld technique and MIG welder, then replace spot welds at top of panel with plug welds. (Use weld-through primers)

j. Smooth weld, prime and apply appropriate seam sealer.

k. Apply sound deadener, if recommended, to inside of skin.

l. Apply color coat to difficult areas, such as inside edge of any portion of the inner panel. Use appropriate refinishing techniques and corrosion protection procedures.

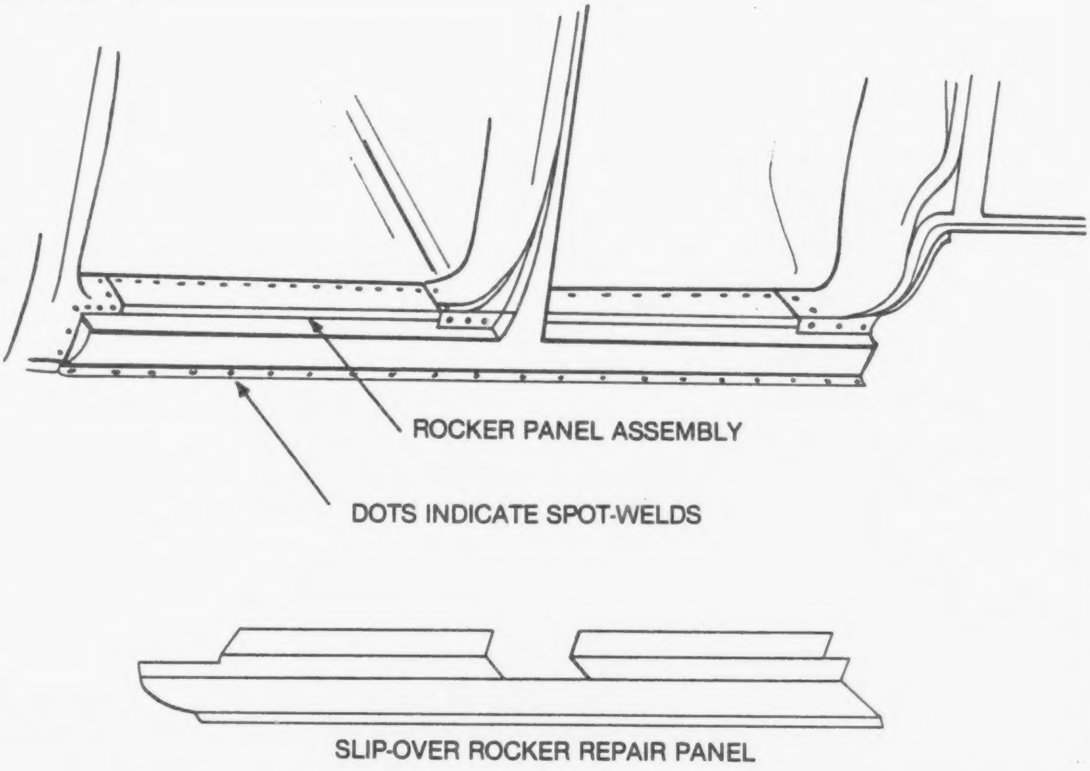
m. Reassemble interior window and lock components and install door. (You may wish to install door first and then reassemble interior components.)

n. Align door following service manual specifications.

J. Rocker panel replacement

1. If rocker panels are seriously damaged they are usually replaced completely, although sometimes damage can be repaired using a slip-over replacement rocker panel. (FIG. 1-3)

FIGURE 1-3



2. In replacing a rocker panel, several points are important:

   a. Interior trim must be removed to gain access to factory weld joints.

   b. Vehicle should be supported under suspension when replacing rocker panel.

   c. Remove rocker panel at factory welds, drilling out factory plug. welds and then using impact tool, as recommended.

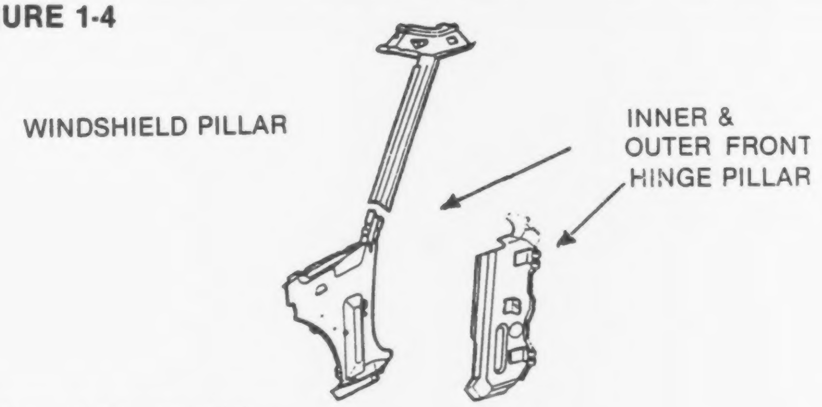
d. Rocker panel has inner and outer panel and may have to be installed as unit or with inner panel first, then outer panel.

e. When replacement rocker panel is properly aligned, grind weld joints, use weld through primers, clamp into position and weld using plug weld techniques to replace factory spot welds.

K. A-pillar (windshield pillar) replacement

1. Damage to either the upper portion (windshield pillar) or the lower portion (front hinge pillar) of the A-pillar may require replacement of the complete pillar. (FIG. 1-4)

FIGURE 1-4



Courtesy of Chrysler Motors

2. In replacing a windshield pillar it may be sectioned using techniques outlined in Module 7.

3. If entire pillar is to be replaced, much of the vehicle interior trim may have to be removed. This is especially true if the roof panel will also be replaced or straightened. When removing interior trim, refer to Exterior and Interior Trim, Module 5. This will include the removal of glass and trim.

4. If severe damage has resulted to roof panel and pillar, frame straightening procedures outlined in Module 7 may be needed. In such cases the damaged pillar and roof panel will be left on vehicle until the straightening operation has been performed.

5. After glass and interior and exterior trim have been removed and panels have been pulled into proper alignment, fender panel should be removed.

6. After removing fender, remove damaged windshield pillar by cutting through the original joints. Drill out factory spot welds, or use impact tool, as recommended.

7. Double check the dimensions of window and door openings before removing the old pillar.

8. After removing old pillar, recheck window and door opening dimensions.

9. Grind away excess metal left by spot welds.

10. Using c-clamps or self-locking pliers, clamp replacement pillar into place.

11. Check fit of windshield and doors before welding.

12. If roof panel has additional damage, straighten and repair at this point.

13. After all adjacent areas of damage have been repaired and alignment of door and windshield openings have been rechecked, weld replacement pillar into place. Use plug welds with MIG welder, using weld-through primer, to replace factory spot welds. Use stitch weld procedure for continuous welds.

14. Grind away welds flush, prepare with proper corrosion protection, plastic filler, etc.

    (NOTE: Whenever replacing panels follow the service manual closely. In the case of unibody structural panels, you must make sure you do not damage high strength steel.)

L. Roof panel

1. The procedure for replacing the roof panel involves reattaching to the roof to the pillars and quarter-panel.

2. All glass openings have to be checked and rechecked during the replacement procedure.

   (NOTE: If at all possible, it is recommended that the roof panel be repaired, rather than replaced.)

M. Fender panel

1. Fender panels are almost always bolted on.

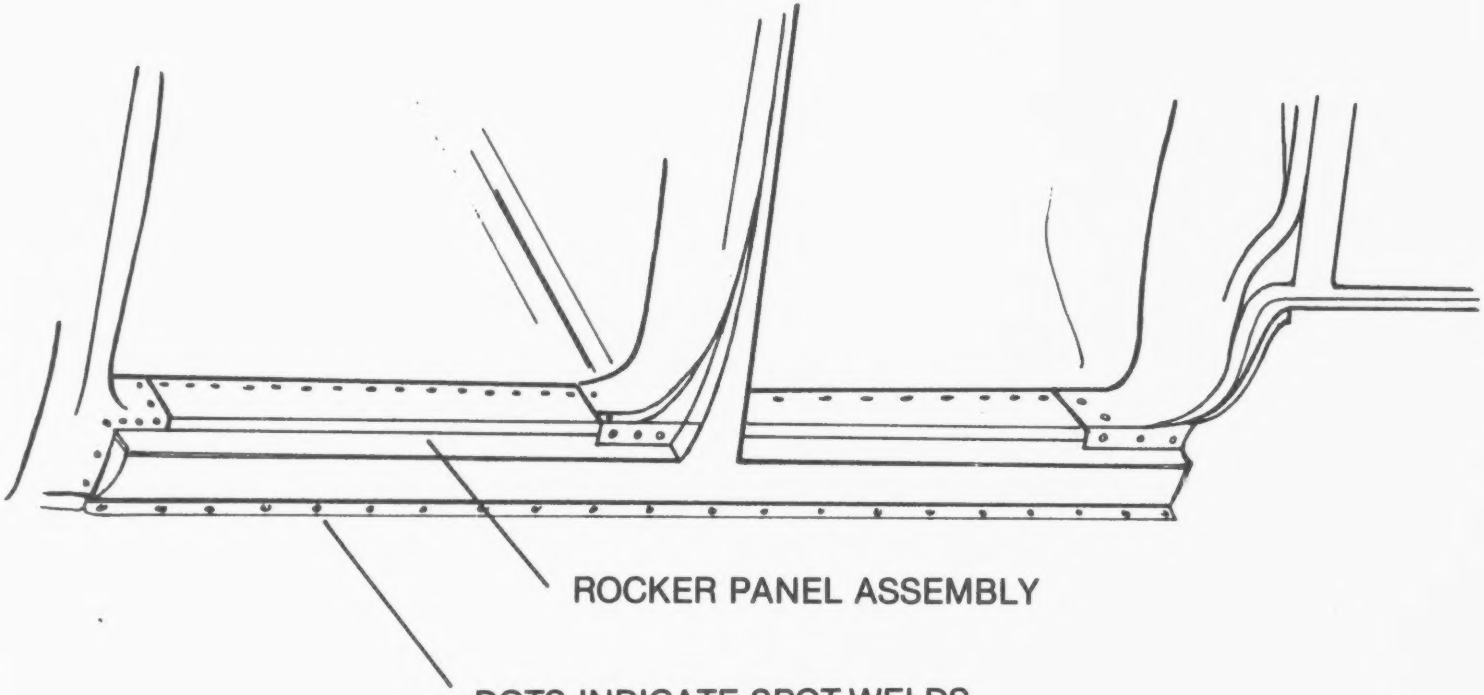
2. In the case of bolted on fender panels, removal and replacement is easily achieved.

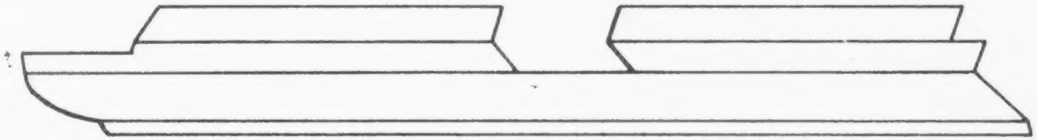
3. Partial replacement of a fender panel (sectioning) is seldom more economical than complete replacement, although it is an acceptable procedure.

4. The inner fender must be checked for damage and repaired or replaced before the outer fender panel is replaced.

5. Follow all corrosion protection procedures.

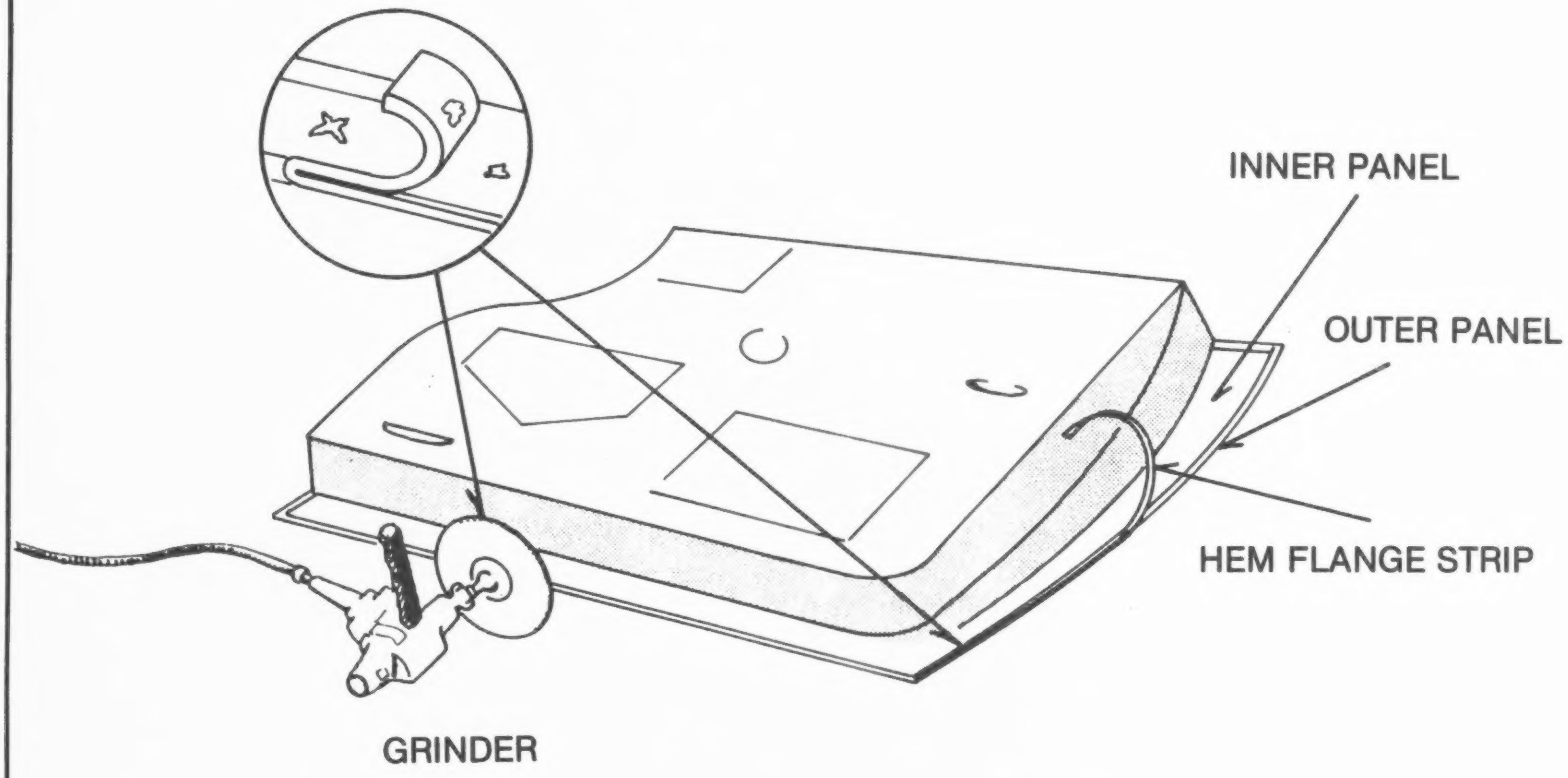
Rocker Panel Assembly


ROCKER PANEL ASSEMBLY
DOTS INDICATE SPOT-WELDS



SLIP-OVER ROCKER REPAIR PANEL

Removing Hem Flange of Door


INNER PANEL
OUTER PANEL
HEM FLANGE STRIP
GRINDER

UNIT III

JOB SHEET #1, LESSON ONE

REMOVE AND REPLACE QUARTER PANEL

Equipment:

Vehicle with quarter panel damage
Vehicle service manual
New quarter panel
New side rail, top gutter to quarter panel, if needed
Special tools as recommended by service manual
Trim adhesive
Seam sealer
Weatherstrip adhesive
Sound deadener
Rust proofing materials
Trunk spatter paint
Electric or pneumatic grinder
MIG welder
Heat gun or torch for heating weatherstrip adhesive
Panel cutter with appropriate chisels
Drill with spot weld cutter bits
Rear window reveal molding tool
Hot or cold knife for removing window
Replacement window seal kit
Fire extinguisher
Personal safety equipment
Cleaning equipment for vehicle

(NOTE: The following job sheet is for evaluation purposes only. Although it will closely approximate the procedure for most vehicles, the service manual procedure must be followed.)

Procedure:

Evaluation:
3 2 1 N

1. Clean vehicle, first with soap and water, then with wax and grease remover. ___ ___ ___ ___
2. Place vehicle on jack stands under rear torque box areas or support vehicle on suspension, then remove rear wheel from damaged side. ___ ___ ___ ___
3. Remove rear bumper. ___ ___ ___ ___
4. Remove gas tank, if necessary for safety. ___ ___ ___ ___
5. Remove interior components which could be damaged by sparks and cover remainder of interior. ___ ___ ___ ___

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
6. If removing panel-to-side rail top gutter, heat adhesive on weatherstrip and remove weatherstrip.				
7. Cut away damaged quarter panel at factory seams and matching flange, drilling out spots welds. Use panel cutter where appropriate.				
8. Trim panel flange from spot weld and straighten all attaching panels to specifications.				
9. Place new quarter panel on vehicle to insure proper fit and alignment. Position new side gutter panel, if needed, in correct location. Plug and stitch weld new panel(s) in position.				
10. Seal with appropriate seam sealer, rust proof interior of new panel and paint trunk with trunk paint, as needed.				
11. Prepare other areas for refinishing or parts replacement, such as tail light area, rear window opening, etc. and refinish.				
12. Install and seal back glass and replace reveal moldings.				
13. Replace interior components removed.				
14. Replace deck lid, taillight(s), and rear bumper and align components.				
15. Prepare and paint new quarter panel, performing appropriate job sheet in Paint and Refinishing Module.				
16. Replace rear wheel, remove jack stand, make final inspections of all work and make any needed adjustments.				
17. Clean exterior and interior of vehicle for delivery to owner.				
Average of above evaluations*				

(*This average is the evaluation for Competency J1 "Remove and replace cosmetic panels, welded on.")

UNIT III

JOB SHEET #2, LESSON ONE

REMOVE AND REPLACE BONDED DOOR SKIN

Equipment:

Vehicle with door skin damage
Vehicle service manual
New door skin
Common hand tools
Special hinge wrenches or pin removal tool, as required
Interior trim panel removal tool
Trim adhesive
Seam sealer
Weatherstrip adhesive
Electric or pneumatic grinder with proper grit disc
Oxyacetylene torch, if necessary
Panel cutter or spot weld drill and bits
Personal safety equipment

(NOTE: The following procedure is based on 3M Door Skin Bonding Kit P.N. 08109. If using another adhesive, the procedure may have to be modified.)

Procedure:	**Evaluation:** 3	2	1	N
1. Remove interior trim panel.	___	___	___	___
2. Remove electric wires or vacuum hoses for power equipment in door, if present, and feed through access hole in front of door, marking components for identification.	___	___	___	___
3. Remove outside mirror, handle lock, and any reusable molding.	___	___	___	___
(NOTE: Door glass can be placed in up or down position as to vehicle service manual or technician's preference.)				
4. Remove door assembly from vehicle.	___	___	___	___
5. Place door assembly on suitable stand or table to remove damaged skin.	___	___	___	___
6. Use grinder to grind through crimped edge of panel. (Power pane cutter may be used).	___	___	___	___
7. Remove damaged outer panel from inner panel, then remove crimped edge of panel with power chisel with spot weld bit or drill with spot weld bit.	___	___	___	___
8. Straighten door inner panel if needed.	___	___	___	___

Procedure:

Evaluation:
3 2 1 N

9. Position new outer panel on door frame and apply medium thin coat of metal primer, with supplied applicator, to all bare metal on the door frame. Use protective clothing and equipment according to adhesive label. ___ ___ ___ ___

10. Prepare applicator gun and adhesive according to instructions and prepare mixing nozzle according to instructions. ___ ___ ___ ___

11. Apply 1/8 inch bead of adhesive to inside of door skin crease or to door skin side of door inner panel. ___ ___ ___ ___

12. Apply door skin to inner panel. Crimp door skin flange in usual manner. (Operation must be completed within 30 minutes from time of adhesive application.) ___ ___ ___ ___

13. Wipe excess adhesive along flange. Apply seam sealer, if desired or required. ___ ___ ___ ___

14. Apply sound deadener and recommended corrosion protection to inside of door. ___ ___ ___ ___

    (Note: Make sure that water drain holes in bottom of door are open.)

15. Apply corrosion protection, undercoat and topcoat inner areas affected by skin replacement. ___ ___ ___ ___

16. Install door on vehicle, adjust to specifications and replace all door interior components and make adjustments needed. ___ ___ ___ ___

17. Refinish exterior of door skin following proper job sheet in Paint and Refinishing Module. ___ ___ ___ ___

18. Replace mirror and exterior trim as needed. ___ ___ ___ ___

    (NOTE: Care should be taken to protect any decals with vehicle identification or other information on them. New decals must be installed if necessary.)

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for Competency J6 "Replace bonded door panels.")

UNIT III

JOB SHEET #3, LESSON ONE

REPLACE WELDED DOOR SKIN AND INTRUSION BARRIER (IF PRESENT)

Equipment:

Vehicle with door skin damage
Vehicle service manual
New door skin
New intrusion barrier
Common hand tools
Special hinge wrenches or pin removal tool, as required
Interior trim panel removal tool
Trim adhesive
Seam sealer
Weatherstrip adhesive
Electric or pneumatic grinder with proper grit disc
Oxyacetylene torch, if necessary
Panel cutter or spot weld drill and bits
Appropriate protective cover for glass
Personal safety equipment

Procedure:

Evaluation:
3 2 1 N

1. Remove interior trim panel. ___ ___ ___ ___

2. Remove electric wires or vacuum hoses for power equipment in door, if present, and feed through access hole in front of door, marking components for identification. ___ ___ ___ ___

3. Remove outside mirror, handle lock, and any reusable molding. ___ ___ ___ ___

   (NOTE: Door glass can be placed in up or down position as to vehicle service manual or technician's preference.)

4. Remove door assembly from vehicle. ___ ___ ___ ___

5. Place door assembly on suitable stand or table to remove damaged skin and intrusion barrier. ___ ___ ___ ___

6. Use grinder to grind through crimped edge of panel. (Power pane cutter may be used). ___ ___ ___ ___

7. Remove damaged outer panel from inner panel, then remove crimped edge of panel and instrusion barrier with panel cutter, or grinder, as appropriate. ___ ___ ___ ___

8. Straighten door inner panel, if needed. ___ ___ ___ ___

Procedure:	**Evaluation:** 3	2	1	N
9. Place intrusion barrier in correct position and weld to specifications.				
10. Position new outer panel on door frame and apply sound deadener and rustproofing to new panel. Hold in place with proper clamps, place a long block of wood under lower outer edge of new panel. Use heavy hammer and flat spoon to crimp flange from 90 degree bend to desired crimp over edge of inner door flange.				
11. Clean and spot weld crimp and flange as necessary, using appropriate personal safety equipment and protecting glass from welding sparks.				
12. Seal entire crimp and flange area with appropriate sealer, insuring that water drain holes in bottom of door are open.				
13. Apply corrosion protection, undercoat and topcoat to inner area affected by skin replacement.				
14. Install door on vehicle, adjust to specifications and replace all door interior components and make final adjustments, if needed.				
15. Refinish exterior of door skin following proper job sheet in Paint and Refinishing Module.				
16. Replace mirror and exterior trim as needed.				
(NOTE: Care should be taken to protect any decals that have vehicle identification or other information on them. New decals must be installed if necessary.)				
Average of above evaluations*				

(*This average is the average for Competency J5 "Replace door intrusion barrier." It may also be used to evaluate Competency J1 "Remove and replace cosmetic panels welded on.")

UNIT III

JOB SHEET #4, LESSON ONE

REMOVE AND REPLACE ROCKER PANEL

Equipment:

Vehicle with rocker panel damage
Vehicle service manual
New rocker panel
Special tools as recommended by service manual
Seam sealer
Weatherstrip adhesive
Sound deadener and rust proofing materials
Electric or pneumatic grinder
MIG welder
Heat gun or torch for heating weatherstrip adhesive
Panel cutter with appropriate chisels
Drill with spot weld cutter bits
Fire extinguisher
Personal safety equipment
Cleaning equipment for vehicle

(NOTE: The following job sheet is for evaluation purposes only. Although it will closely approximate the procedure for most vehicles, the service manual procedure must be followed.)

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
1. Clean vehicle, first with soap and water, then with wax and grease remover.	___	___	___	___
2. Place vehicle on jack stands under rear torque box areas or support under suspenions, then remove front and rear wheel from damaged side.	___	___	___	___
3. Remove door(s) by performing appropriate job sheet, this lesson.	___	___	___	___
4. Remove interior components which could be damaged by sparks and cover remainder of interior.	___	___	___	___
5. Use appropriate straightening equipment and measuring equipment to pull damaged panel(s) into alignment. Follow procedures outlined in Fram Repair Module.	___	___	___	___
6. Cut away damaged rocker panel at factory seams and matching flanges, drilling out spots welds. Use panel cutter where appropriate or grinder.	___	___	___	___

Procedure: **Evaluation:**
3 2 1 N

7. Trim panel flange from spot weld and straighten all attaching panels to specifications. ___ ___ ___ ___

8. Apply corrosion protection, body filler, and refinish attaching panels, as needed. ___ ___ ___ ___

9. Place new rocker panel on vehicle to insure proper fit and alignment. Clamp into position and plug and stitch weld new panel in position. ___ ___ ___ ___

10. Grind welds flush and prepare weld areas and panel for refinishing, applying filler and corrosion protection as required. ___ ___ ___ ___

11. Peplace doors and align. ___ ___ ___ ___

12. Refinish rocker panel using appropriate job sheet in Paint and Refinishing Module. ___ ___ ___ ___

13. Replace wheels, remove jack stands, make final inspections of all work, then clean exterior and interior of vehicle for delivery to owner. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the student's final evaluation for competency L2 "Remove and replace structural panels, welded on.")

(NOTE: Although this job sheet is the only one present for evaluating competency J2 "Remove and replace structural panels welded on." The competencies could be evaluated by other means. A rocker panel was chosen for the job sheet due to the relative simplicity of replacement. However, if the student were to replace a body rail, a pillar, or a trunk floor, this would also serve to evaluate the competency. In such a case, and due to the variety of vehicle designs, the instructor should devise a job sheet.)

UNIT V

JOB SHEET #5, LESSON ONE

SECTION QUARTER PANEL

Equipment:

Vehicle with quarter panel damage
Vehicle service manual
New quarter panel or section
Special tools as recommended by service manual
Trim adhesive, if needed
Seam sealer, if needed,
Weatherstrip adhesive, if needed
Sound deadener
Rust proofing materials
Trunk spatter paint
Electric or pneumatic grinder
MIG welder
Heat gun or torch for heating weatherstrip adhesive, if needed
Panel cutter with appropriate chisels
Drill with spot weld cutter bits, if needed
Rear window reveal molding tool, if needed
Hot or cold knife for removing window, if needed
Replacement window seal kit, if needed
Fire extinguisher
Personal safety equipment
Cleaning equipment for vehicle

(NOTE: Due to the many variations of this procedure it is suggested that the students develop their own job sheet. The student can use Job Sheet #1 "Remove and replace quarter panel," as a guide. That procedure will be similar, except that the panel will not be replaced at factory seams. You instructor will have to demonstrate procedures for fitting and welding the section in place.)

(This will be the evaluation for Competency J4, "Section non-structural panels, welded on.")

MODULE: PANEL REPAIRS

UNIT III: PANEL REPLACEMENT

LESSON TWO: ALIGNING PANELS

I. **Terms and definitions:**

   A. Fore and aft -- Forward and backward.

   B. Functioning moveable panel -- Bolted-on parts of the vehicle that serve a purpose other than cosmetic (such as hood, door and deck lid).

   C. Non-Functioning moveable panel -- Panels that serve no other purpose than cosmetic, such as fenders.

II. **Principles of aligning moveable cosmetic panels**

   A. Frequent need for panel alignment

      1. Alignment of panels that are detachable and adjustable is an everyday operation in the auto body repair industry.

      2. Adjustments are frequently made on vehicles that are not even damaged. A customer might complain that a door is difficult to close, or that a trunk lid leaks during heavy rain.

      3. Panels are not always perfectly aligned at the factory. Slight misalignments can occur in transportation between factory and dealership. And, of course, there is the requirement that panels be realigned during collision repairs.

      4. Remember that a panel must appear aligned as well as be aligned. It is possible for a properly aligned panel to look misaligned. It is also possible for a misaligned panel to appear aligned.

   B. The two types of moveable cosmetic panels

      1. Functioning panels

         a. Doors

         b. Hoods

         c. Deck lids (also referred to as trunk lids.)

      2. Non-functioning panels

         a. Fenders

      3. Functioning moveable panels must be aligned so that they properly perform their function as well be as aligned for their appearance.

      4. Non-functioning moveable panels (fenders) should be aligned for appearance only, since they do not move.

5. In aligning panels, it is important to understand which panels should be aligned with which panels

   a. Stationary panels must be aligned properly before moveable panels are aligned.

   b. Once stationary panels are aligned, moveable panels can be aligned with stationary panels

   c. Once moveable panels which align to stationary panels are aligned, then moveable panels which align to other moveable panels can be aligned.

   (NOTE: Since fenders are aligned with the hood and the door, the hood and the door must be aligned with the stationary panels adjacent to them first. Then the fender is aligned to the hood and door. The fender is never used as an alignment guide for the door or hood. Also, rear doors must be aligned with the quarter panel before front doors are aligned.)

III. The alignment process

A. The three steps in the alignment process

   1. Know where the panel is now.

   2. Know where the panel should be moved.

   3. Determine how best to move it.

B. Body panel alignments require frequent referral to manufacturer's shop manuals. These manuals specify the adjustments that are available and provide details of assemblies, such as the operation of hinges and locking mechanisms.

C. In aligning the panels the proper clearances must be checked in the shop manual. In general, clearances will be 3/16 inch, plus or minus 1/16 inch. Check the shop manual to be sure. (FIG. 2-1)

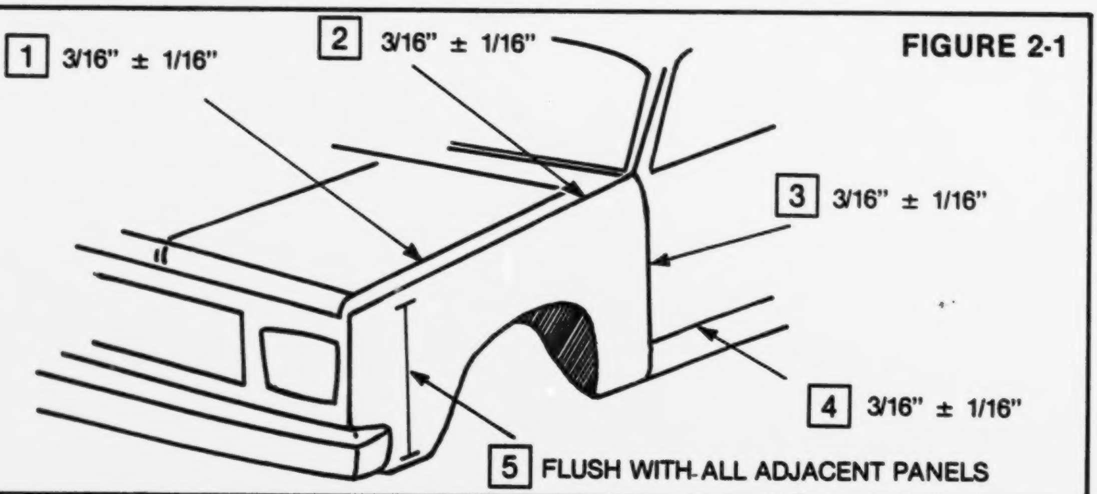


FIGURE 2-1

D. Methods of adjusting panels

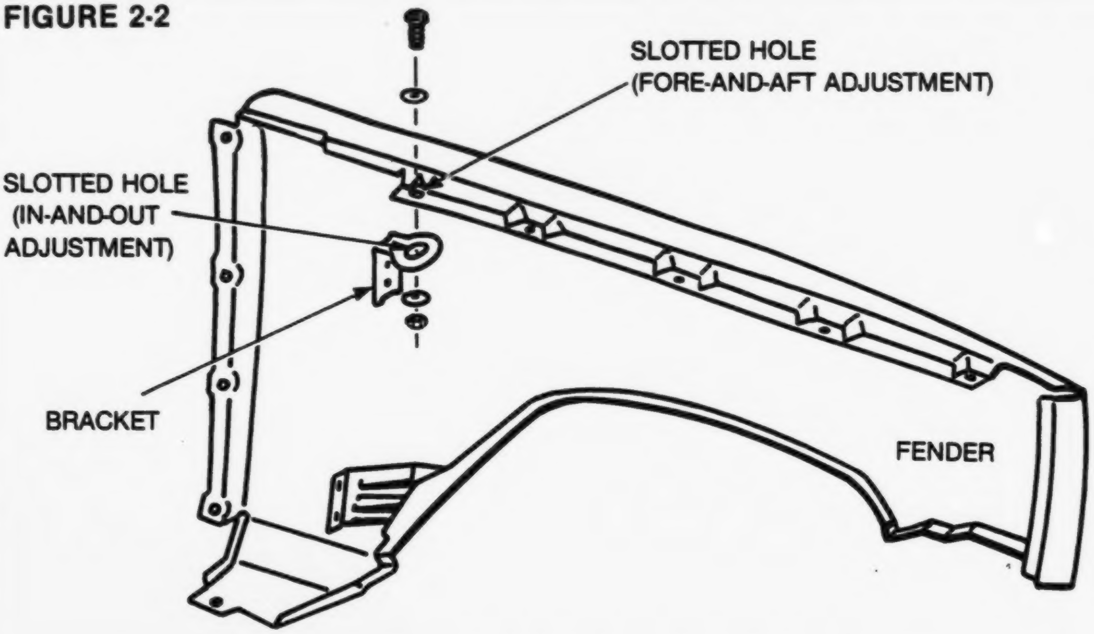
1. Slotted holes
2. Caged plates
3. Adjustable stops
4. Shims

E. In making alignments, each panel will use different means of making adjustment

1. Doors may be adjusted through caged plates or by special tools which bend the hinge, depending on whether the door is welded or bolted on.
2. Fenders may be adjusted through slotted holes, allowing fore and aft movement, or shims. Some slotted holes may allow fender adjustment inward and outward.
3. Hoods may be adjusted using shims. Also the height of the front of the hood may be adjusted using an adjustable stop.
4. Decks may be adjusted by using shims.

F. Slotted holes (FIG. 2-2)

FIGURE 2-2

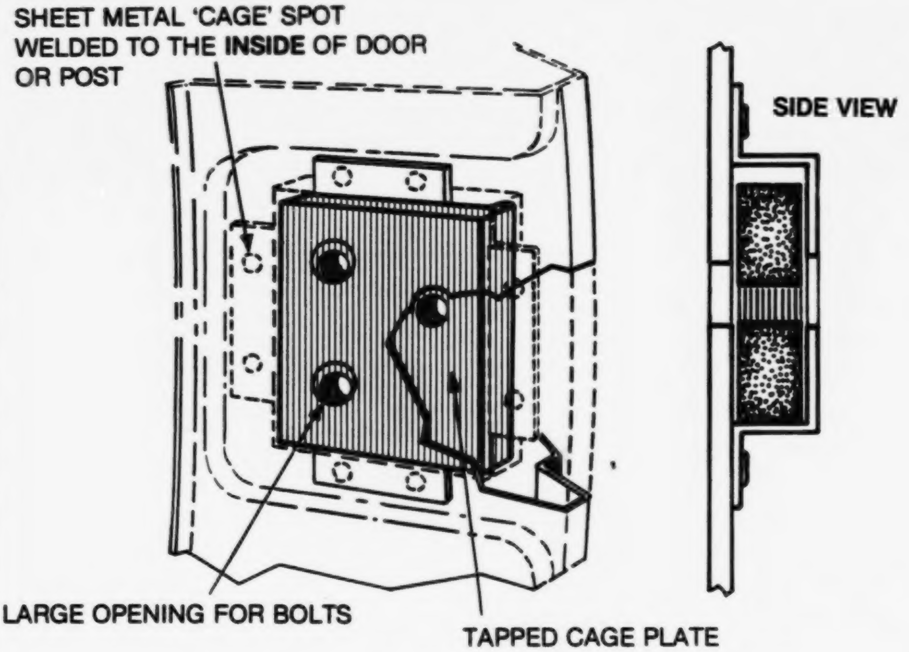


1. Allow part to be shifted into position before the bolts are tightened.
2. Usually require a large flat washer to provide added strength and grip

3. Commonly found on fender and hood panels

G. Caged plates (FIG. 2-3)

FIGURE 2-3


SHEET METAL 'CAGE' SPOT WELDED TO THE INSIDE OF DOOR OR POST
SIDE VIEW
LARGE OPENING FOR BOLTS
TAPPED CAGE PLATE

1. Commonly found on hinge pillars or inner door

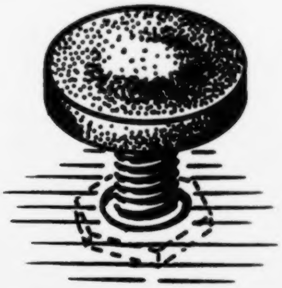
2. Needed for multidirectional adjustment – caged plate allows movement in all directions.

   (Without the caged plate, even a strong flat washer would fail to provide adequate strength.)

3. Cannot be seen because they are inside the door panel or hinge pillar.

H. Adjustable stops (FIG. 2-4)

FIGURE 2-4



1. Used often on hood

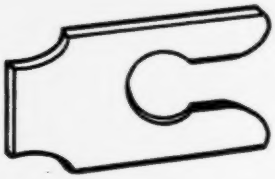
2. Control height of panel

3. Are large bolts threaded toward the bottom, which screw into fixed nut that has a lock nut on top of it to hold the adjustable stop in position

4. Usually have a rubber cap on top to keep stop from rattling and prevent chipping paint on underside of hood

I. Shims (FIG. 2-5)

FIGURE 2-5



1. Commonly used on fenders and deck lids

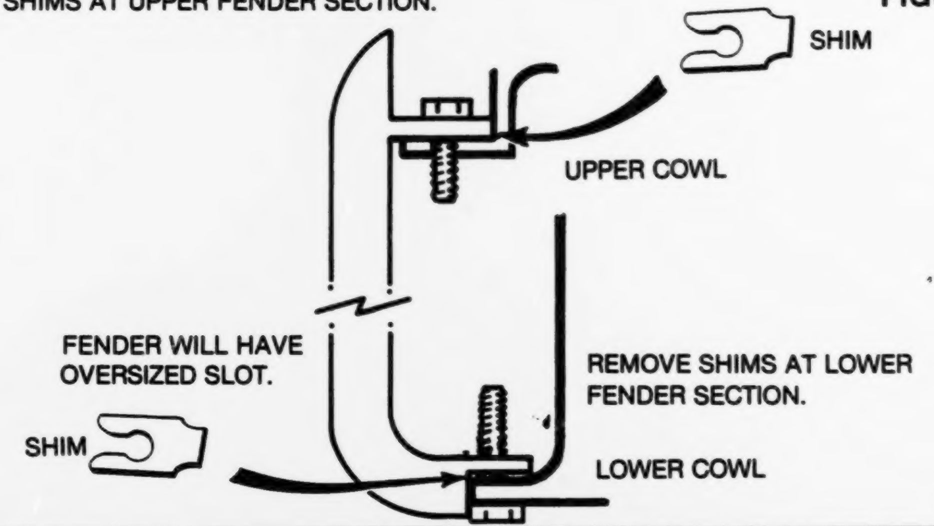
2. Are small wedges of metal used to change the distance between two parts

3. Are designed so that they can be slipped around bolts holding two parts together without removing the bolt

4. Are always positioned around the bolt and between the two parts.

5. When adding a shim to the upper fender section to raise the fender, a shim will have to be removed from the lower section to compensate. (FIG. 2-6)

FIGURE 2-6


ADD SHIMS AT UPPER FENDER SECTION.
SHIM
UPPER COWL
FENDER WILL HAVE OVERSIZED SLOT.
REMOVE SHIMS AT LOWER FENDER SECTION.
SHIM
LOWER COWL

UNIT III

JOB SHEET #1, LESSON TWO

REMOVE AND REPLACE A HOOD

Equipment:

Vehicle
Vehicle service manual
Common hand tools
Shims
Marking device, such as soapstone or awl
Hinge lubrication
Tape measure
Personal safety equipment

Procedure:	**Evaluation:** 3 2 1 N
1. Before removing hood, check hinge operation and lubricate hinge. If hinge parts are defective, replace them following removal of the hood.	__ __ __ __
2. Mask finish along edges of fenders and cowl panel to protect from damage during removal or replacement.	__ __ __ __
3. If hood is from larger vehicle, have a helper work with you. First mark the bolt locations on hood-to-hinge attachment, then remove the bolts holding the hood.	__ __ __ __
4. If bolt locations were marked on hood hinge attaching points, measure and mark them on the replacement hood. *(NOTE: If replacement hood requires refinishing, refinish edges and underside of hood at this time.)*	__ __ __ __
5. Position replacement hood, with helper, on hinges and replace bolts in same location as marked.	__ __ __ __
6. Carefully close hood and check alignment. Gap between fender and hood on each side should be equal and should be 1/8 inch to 1/4 inch on each side. Too narrow or too wide of gap indicates fender misalignment. Check gap between cowl panel and hood. Gap should be 1/8 inch to 1/4 inch wide. Then check height of hood. Hood should be flush with fenders and cowl all the way around.	__ __ __ __

Procedure: **Evaluation:**
3 2 1 N

7. Based on observations in step 6, make adjustments by the following means: ___ ___ ___ ___

   a. If gap between cowl and hood is wrong loosen bolts holding hood to hinge and slide forward or backward, as appropriate.

   b. If hood is too high or too low at cowl adjust height by loosening bolts holding hinge to fender on each side and raising or lowering hinge as required. Mark position of bolts before loosening bolts.

   c. If hood height cannot be properly adjusted with hinge-to-fender adjustment, then use shims under bolts holding hood to hinge.

      (NOTE: Placing a shim under the front bolt position will lower the hood and placing a shim under the rear bolt position will raise the hood.)

   d. If hood height at front edge of fenders and grille assembly is too high or too low, raise or lower adjustable rubber stops, if present. If not present, consult service manual for procedure on adjusting stationary rubber stops).

8. Check alignment of hood latch. If adjustment is needed, loosen bolts holding latch to radiator support and adjust in proper direction. Tighten and check, then repeat procedure until hood is properly aligned. ___ ___ ___ ___

   (NOTE: Before adjusting latch assembly, make sure that latch on hood is not bent).

9. After making all adjustments, open and close hood several times to check alignment and then remove masking tape. If hood is to be refinished, then perform proper job sheet from Paint and Refinishing Module. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average may be used as the evaluation for competency J3 "Remove and replace cosmetic panels bolted on.")

UNIT III

JOB SHEET #2, LESSON TWO

REMOVE AND REPLACE A FENDER

Equipment:

Vehicle with fender damage
Vehicle service manual
Common hand tools
Shims
Tape measure
Personal safety equipment

Procedure:

		Evaluation: 3	2	1	N
1.	Remove bumper, if necessary.	___	___	___	___
2.	Apply masking tape to any adjacent panels which could be scratched during removal.	___	___	___	___
3.	Open hood and remove top bolts. *(NOTE: Record presence and location of any shims).*	___	___	___	___
4.	Remove other bolts, as required. Check service manual for locations. Locations may include front end panel, valance panel, tie bar, etc. Note presence and location of any shims.	___	___	___	___
5.	Remove fender and repair any damage to inner fender or damage to attachment points to other panels. Restore any corrosion protection present.	___	___	___	___
6.	Refinish and restore corrosion protection to inside surfaces of replacement fender.	___	___	___	___
7.	Carefully position replacement fender and reattach bolts, replacing shims in proper locations.	___	___	___	___
8.	Before fully tightening bolts, check alignment. There should be 1/8 inch to 1/4 inch gap between hood, door, valance panel, or other panels. Fender surface should be flush with all adjacent surfaces.	___	___	___	___
9.	Remove or add shims of proper size to bring fender into proper alignment.	___	___	___	___

Procedure:

	Evaluation:			
	3	2	1	N
10. Refinish fender by performing appropriate job sheet from Paint and Refinishing Module.	___	___	___	___
11. Replace any moldings or emblems on fender. Refer to appropriate job sheet in Exterior and Interior Trim Module.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average may be used as the evaluation for competency J3 "Remove and replace cosmetic panels bolted on.")

UNIT III

JOB SHEET #3, LESSON TWO

REMOVE AND REPLACE DOOR

Equipment:

Vehicle service manual
Common hand tools
Tape measure
Marking device, such as soapstone or awl
Wooden block and heavy hammer
Special hinge wrenches or pin removal tool, as required
Personal safety equipment

(NOTE: Due to the large variety of door attachment methods, the following job sheet is for evaluation purposes only. Follow service manual procedures for removal, replacement and alignment.)

Procedure:

Evaluation:
3 2 1 N

1. Mask adjacent areas which could be damaged during door removal. ___ ___ ___ ___

2. Mark location of door on hinges, or of door hinge on pillar, or both if adjustments are possible at both places. Note any shims present. ___ ___ ___ ___

3. Remove bolts or pin as appropriate according to service manual and remove door. ___ ___ ___ ___

   (A helper will usually be necessary.)

4. After performing service work on door, if needed, position door and replace pin or bolts as required. ___ ___ ___ ___

5. Check door alignment. Gap should be 1/8 inch to 1/4 inch along all adjacent surfaces. ___ ___ ___ ___

6. Make adjustments, if needed, by loosening appropriate adjustment bolts, following service manual procedures. Trial and error may be required. ___ ___ ___ ___

7. If necessary, use shims to make further adjustments. ___ ___ ___ ___

Procedure: **Evaluation:**
3 2 1 N

8. Check operation of door latch assembly. If adjustment is needed, loosen striker bolt and reposition striker bolt.

   Repeat if necessary until alignment is correct. ___ ___ ___ ___

   (NOTE: Sometimes it is easiest to use modeling clay to determine where striker must be moved to. Simply take modeling clay and smooth gently over latch assembly, then carefully move door against striker, being careful not to close door. Move door away from striker and note impression on modeling clay and make adjustment accordingly.)

   Average of above evaluations* ___ ___ ___ ___

   (*This average may be used as the evaluation for Competency J3 "Remove and replace cosmetic panels bolted on.")

UNIT III

JOB SHEET #4, LESSON TWO

ALIGN A DECK LID

Equipment:

Combination-end wrenches
Common hand tools
Soapstone or scratch awl
Tape measure
Assorted shims
Water hose and power nozzle
Replacement weatherstripping and adhesive (if necessary)
Appropriate service manual
Personal safety equipment

Procedure: **Evaluation:**

3 2 1 N

1. Close deck lid and check clearances. All clearances should be within 3/16" plus or minus 1/16" and deck lid should be flush with adjacent panels. Check manufacturer's specifications to be sure. ___ ___ ___ ___

2. Align fore and aft location. ___ ___ ___ ___

    a. Open deck lid.

    b. Mark attachment bolts with scratch awl.

    c. Loosen bolts on one side only.

    d. Move deck lid forward or back to desired location.

    e. Tighten bolts and repeat procedure for the other hinge if necessary.

    f. Close deck lid and check for desired alignment.

3. Align a deck lid height by using shims. ___ ___ ___ ___

    a. Close the deck lid and note misalignment. Measure distance of misalignment to judge how thick shim should be.

    b. Mark bolts with the scratch awl to obtain original location.

Procedure: **Evaluation:**

3 2 1 N

c. Loosen bolts on one side only.

d. Place shim (or shims) between hinge and lid at the bolt. If lid is low at hinge edge, place shims at front of hinge. If lid is high at hinge edge, place shims at rear of hinge.

e. Check alignment with scratch awl marks and tighten bolts. Close lid and check for proper height.

f. Repeat process until proper alignment is achieved.

4. Align the deck lid latch (side-to-side). ___ ___ ___ ___

a. Mark latch adjusting bolts with scratch awl.

b. Lower deck lid until striker bar comes into contact with the top of the latch assembly.

c. Analyze the position of latch to strike.

(NOTE: With deck lid properly adjusted, if the bar does not fit squarely into the latch, side to side adjustment is necessary.)

d. Tighten bolts, close lid slowly and check alignment.

5. Align the deck lid latch height. ___ ___ ___ ___

a. Close the deck lid.

(NOTE: If the lid requires extreme pressure to shut, adjust the latch up; if the lid has slack in it, the latch is too high.)

b. Mark bolts with the scratch awl.

c. Loosen bolts and adjust to desired position.

Procedure: **Evaluation:**
3 2 1 N

- d. Tighten bolts and check position of lid.

- e. Repeat steps until desired position is reached.

6. Check deck lid seals. ___ ___ ___ ___

   - a. Close deck lid and check alignment.

   - b. Apply water from a hose directly between the gap around the lid.

   - c. Open deck lid and check weather stripping for wet spots.

     (NOTE: If water has traveled across the weather stripping and into the trunk, a new seal may be required.)

   - d. Check weather stripping for flaws. Repair with proper adhesive.

   - e. Check factory solder or weld joints.

     (NOTE: Low factory joints will not allow weather stripping to meet the lid properly. Check for proper procedure to make repairs.)

   - f. Re-check deck lid with stream of water. If lid still leaks, check for other proplems or repeat procedure.

Average of above evaluations* ___ ___ ___ ___

(*This average may be used as the evaluation for Competency J3 "Remove and replace cosmetic panels bolted on.")

MODULE: PANEL REPAIR AND REPLACEMENT

UNIT III: PANEL REPLACEMENT

UNIT III TEST

PART I–PANEL REPLACEMENT

I. Match the term in the right column with the most closely associated term or definition in the left column.

_____1. Moveable panel covering the trunk

_____2. Panel covering front wheel on each side of the front of vehicle

_____3. Panel which does not contribute significantly to vehicle strength

_____4. Exterior portion of door panel often replaced by itself

_____5. Moveable panel covering the engine compartment

_____6. Box section panel which supports the roof panel

_____7. The panel on the vehicle at each corner of the rear of the vehicle

_____8. The panel located at the lower, outside edge of the passenger compartment

_____9. A portion of a panel

A. Cosmetic panel

B. Hood

C. Rocker panel

D. Side panel

E. Deck

AB. Pillar

AC. Section

AD. Quarter panel

AE. Door skin

BC. Fender

II. Select the best answer from the choices listed.

_____10. A panel which is not replaced, since damage severe enough to require replacement almost always means the vehicle cannot be economically repaired, is the: (a) deck, (b) quarter panel, (c) body rail, (d) trunk floor, (e) floor panel.

_____11. A panel which is usually bolted on, even in unibody vehicles is the: (a) fender, (b) A-pillar, (c) rocker panel, (d) door skin, (e) body rail.

_____12. When replacing welded panels it is best to replace them: (a) as soon as possible, (b) with an oxyacetylene torch, (c) at factory seams, (d) with a panel spotter, (e) with bolts.

_____13. Whenever replacing more than one panel, the one you should replace first is the: (a) cosmetic panel, (b) stationary panel, (c) adjustable panel, (d) highest panel, (e) lowest panel.

_____14. When using a disc grinder in the area of the fuel tank or fuel filler opening, you should: (a) use a respirator, (b) keep a fire extinguisher nearby, (c) use a spark reducer, (d) remove the fuel tank, (e) all of the above.

_____15. A non-structural panel which is frequently sectioned is the: (a) dust panel, (b) A-pillar, (c) door skin, (d) fender, (e) quarter panel.

_____16. If more than one door on the same side of the vehicle is damaged you should: (a) check for rocker panel damage, (b) check for quarter panel damage, (c) repair the rear door first, (d) repair the front door first, (e) repair the most heavily damaged one first.

_____17. When replacing factory spot welds the recommended technique is to use: (a) stitch welds, (b) plug welds, (c) resistance spot welds, (d) gas welds, (e) adhesive welds

_____18. A panel which is sometimes attached by adhesives is the: (a) dust panel, (b) fender, (c) side panel, (d) B-pillar, (e) door skin.

(NOTE: Completion of this portion of the test with a minimum score of ____ is necessary for the student to receive evaluations on the job sheets in Lesson One.)

PART II--PANEL ALIGNMENT

______19. A type of adjustment often found in door panels is the: (a) slotted hole, (b) caged plate, (c) adjustable stop, (d) shim, (e) none of the above.

______20. A type of adjustment often found in rocker panels is the: (a) slotted hole, (b) caged plate, (c) adjustable stop, (d) shim, (e) none of the above.

______21. Function is as important as appearance in the alignment of all of the following panels except: (a)hood, (b) deck lid, (c) fenders, (d) doors.

______22. A door is being aligned. Technician I says to align the door to the hinge pillar and fender. Technician II says to align the door to the rocker panel and hinge pillar. Who is right? (a) I only, (b) II only, (c) both I and II, (d) Neither I nor II.

______23. Gaps between movable panels should: (a) Permit easy opening and closing, (b) Avoid rubbing contact between panels, (c) a and b, (d) neither a nor b.

______24. All of the following panels are used as guides in door alignment except: (a) rocker panel, (b) hinge pillar, (c) fender, (d) roof panel.

______25. A very slight misalignment exists between deck lid and opening. You should: (a) reshape the edge of the opening slightly with a mallet or hammer, (b) not worry about a slight misalignment, (c) check to see that the dimensions of the opening are correct, (d) all the above, (e) none of the above.

______26. Which is the least important gap to be considered when aligning a hood? (a) the one at the rear, closest to the windshield, (b) the one at the fender, (c) both a and b, (d) neither a nor b.

______27. Hoods and deck lids share all the following parts except: (a) hinges, (b) striker plates, (c) locking mechanisms, (d) weather sealing.

______28. Which is the initial adjustment when aligning a fender? (a) align for proper gap with the hood, (b) adjust so fender is flush with door outer panel, (c) align for proper gap with the front edge of the door, (d) align bottom of fender with rocker panel, (e) b and c.

_____29. A caged plate is a panel adjusting device which would most likely be found on the: (a) fender, (b) hood, (c) door, (d) deck lid, (e) lock pillar.

_____30. If you needed to align a quarterpanel, a rear door, a front door and a fender on the same side of a vehicle, which of the following would be the order in which you would align the panels: (a) fender, front door, rear door, quarter panel, (b) front door, rear door, fender, quarterpanel, (c) fender, quarter panel, rear door, front door, (d) quarter panel, rear door, front door, fender, (e) quarter panel, fender, rear door, front door.

_____31. Moveable panels must be aligned properly before stationary panels are aligned because: (a) You can always re-adjust moveable panels, (b) Stationary panels can be reshaped, (c) You must align to the fender, (d) You must align to the doors, (e) None of the above.

_____32. Technician I says that on a four-door vehicle you must align the front door first, since it is the hardest to align. Technician II says that on a four-door vehicle you must align the rear door first because the rear door must align with the quarter panel. Who is right? (a) Technician I only, (b) Technician II only, (c) both I and II, (d) neither I nor II.

(NOTE: Completion of Part Two of this unit test with a minimum score of _________ is necessary for the student to receive an evaluation on the Job Sheets in Lesson Two.)

ANSWERS TO UNIT III TEST

PART I.

1. E
2. BC
3. A
4. AE
5. B
6. AB
7. AD
8. C
9. AC

10. E
11. A
12. C
13. B
14. D
15. E
16. C
17. B
18. E

PART II.

19. B
20. E
21. C
22. B
23. C
24. C
25. C
26. B
27. D
28. E
29. C
30. D
31. E
32. B

MODULE: PANEL REPAIRS

UNIT IV: PLASTIC REPAIR

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify plastic types and be able to repair various kinds of plastics. Mastery will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit the student should be able to:

Lesson 1:

I. Identify types of plastics (Competency H1, Part I of Unit IV test)

II. Identify plastic repair techniques (Competencies H2 - H7, Part II of Unit IV test)

III. Demonstrate the ability to:

  a. Clean exterior and interior surfaces (Competency H3, Job Sheet #1)

  b. Identify plastic type and analyze damage to plastic panels (Competencies H1 and H2, Job Sheet #2)

  c. Perform airless welding (Competency H5, Job Sheet #3)

  d. Perform chemical plastic welding (Competencies H4, H6, K4, Job Sheet #4)

  e. Repair a plastic dash (Competency H7, Job Sheet #5)

  f. Re-texture plastic dash panel (Competency H7, Job Sheet #6)

MODULE: PANEL REPAIRS

UNIT IV: PLASTIC REPAIR

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

    1. Lesson 1: Plastic Panel Repair

        a. Information outline

        b. Job sheets:

JS#1:	Clean plastic exterior and interior surfaces
JS#2:	Identify plastic type and analyze damage to plastic panels
JS#3:	Perform two-sided airless plastic weld on ABS
JS#4:	Use adhesives to repair a puncture or small tear in urethane plastic bumper
JS#5:	Repair vinyl-clad urethane foam dash
JS#6:	Re-texture platic dash

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Due to the variety of plastics, the instructor should feel free to modify the job sheets in this unit to reflect the type of plastic and the exact weld needed.

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3. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL 1984.

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MODULE: PANEL REPAIRS

UNIT IV: PLASTIC PANEL REPAIR

LESSON ONE: PLASTIC REPAIR

I. **Plastic Identification**

   A. Terms and definitions

      1. Airless plastic welder -- A type of plastic welder which uses heating elements to melt a plastic welding rod and to heat the material to be welded.

      2. Hot-air plastic welder -- A type of plastic welder which uses forced hot air to melt a plastic welding rod and to melt the material to be welded.

      3. Plastic -- Broad term for any type of polymer, which is a man-made, petroleum-based, organic compound. Plastics are distinguished by their organic nature, ability to be easily molded, and by their relatively low melting temperatures. Although plastics have traditionally been low in strength, some modern plastics are as strong as most metals.

         (NOTE: The word plastic means "the ability of something to be easily molded into a new shape." When the first polymers were created, the word plastic was used to describe them.)

      4. Thermoplastics -- Any plastic which, when heated, can be reshaped without losing its original properties. Thermoplastics can be heated and cooled over and over.

      5. Thermosetting plastic -- Any plastic which, when heated, cannot be reshaped without losing its original properties. Once thermosetting plastics have been formed they cannot be reshaped, although they can be repaired in many cases.

      6. Urethane -- Name for a family of plastics derived from the same root compound. Different urethanes may have vastly different properties.

      7. Weld-bond -- Repair technique for thermosetting plastics where the plastic is heated to a point where, without melting or breaking down, it will bond with a melted plastic welding rod.

   B. Growth of plastic use in vehicles

      1. Due to their lighter weight per volume than metal components, plastic parts have been used in vehicle construction in an effort to increase vehicle fuel efficiency.

      2. In the past most plastic components were interior components or underhood components.

      3. Due to recent advances in plastic technology, more and more vehicle exterior parts are being made of plastic.

4. As plastic technology advances plastic will be used for more and more vehicle parts.

5. Although current plastic application is limited to cosmetic-type panels, some industry-watchers are predicting that cars of the not-too-distant future will be made almost entirely out of plastic.

6. Regardless of how widespread the use of plastic becomes, plastic repair is already an important part of vehicle repair and it may soon become as important as metal repair

C. Types of plastics

1. Plastics fall into two main categories: thermoplastics or thermosetting plastics.

2. Thermoplastics can be heated, reshaped, and cooled many times and can be welded with airless or hot-air welders.

3. Thermosetting plastics cannot be reshaped with heat after they are initially formed, but some thermosetting plastic can be weld-bonded with airless plastic welding equipment. Some thermosetting plastics can also be repaired using adhesives.

4. The two most common thermoplastics in vehicle parts (also the two most common interior hard plastics) are ABS and polypropylene.

5. The most common thermosetting plastic, used on interior and exterior parts, is thermoset polyurethane (PUR).

D. Common thermoplastics and their universal symbols

(NOTE: This is not a complete list. New plastics and blends of plastics are being created all the time.)

1. ABS (acrylonitrile-butadiene-styrene)
2. ABS/PVC (ABS/vinyl)
3. PC (polycarbonate, also known as Lexan)
4. PE (polyethylene)
5. PP (polypropylene)
6. PS (polystyrene)
7. PVC (polyvinyl chloride, also known as vinyl)
8. TPO (thermoplastic olefin)
9. TPUR (thermoplastic polyurethane)

E. Common types of thermosetting plastics

(NOTE: This is not a complete list. New plastics and blends of plastics are being created all the time.)

1. E/P, EP-I, EP-II, EPDM (All are different forms of ethylene propylene and are members of the polyolefin family.)

2. PA (polyamide - also know as nylon)

3. PPO (polyphenylene oxide, also known as noryl)

4. PUR (thermoset polyurethane)

5. RIM (reaction injection molded polyurethane)

6. R.RIM (reinforced RIM)

7. SAN (styrene acrylonitrile)

8. TPR (thermoplastic rubber)

F. Polyester (UP) and epoxy (EP) are types of plastics used in making fiberglass, which is a mixture of plastic (resin) and glass fibers. They can be repaired with fiberglass repair methods, which are outlined in Unit V. One new fiberglass-type material is sheet molded compound (SMC).

(**CAUTION:** *SMC requires special repair procedures and repair materials. Consult manufacturer's recommendations for SMC repair.)*

G. Another important plastic category is the polyolefins.

1. One polyolefin is a thermoplastic (TPO) and the rest are thermosetting.

2. Polyolefins must be identified because they require an adhesion promoter for both adhesive repair and refinishing.

3. TPO, E/P, EP-I, EP-II and EPDM are all polyolefins.

4. Polyolefins can be recognized due to their greasy appearance when sanded and the fact that they do not sand to a smooth surface.

H. Identification procedures

(NOTE: You cannot tell a plastic type by its appearance.)

1. The easiest way to tell a plastic is to refer to the shop manual or to the parts supplier. Also, the plastic symbol may be stamped onto the part.

2. If identification is not known from the shop manual, parts supplier, or a symbol on the part, there are two methods of identifying the plastic - the burn test and the melt test.

3. The burn test

   a. The burn test cannot tell with certainty the type of plastic. However, it narrows the possibilities of the type of plastic down such that a melt test can be performed more quickly.

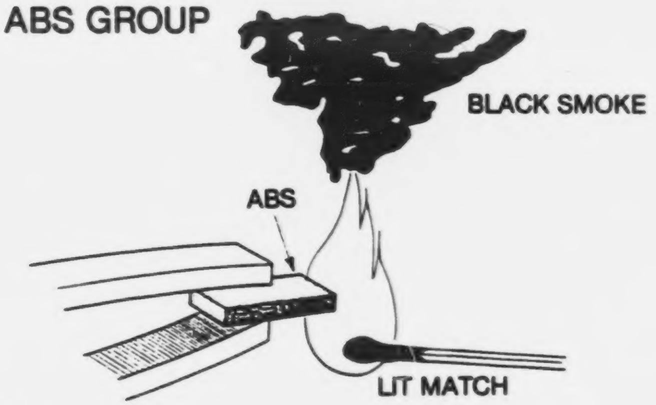
   b. The burn test is done by removing a small sliver of plastic from a non-visible portion of the panel.

   c. Hold the silver with a pair of pliers and ignite it with a match. According to the way the plastic burns, you may be able to correctly identify it.

4. Burn characteristics of four common plastics

   a. ABS – Burns with thick, black, sooty smoke which hangs in the air. Plastic continues to burn when flame is removed. Has a characteristic odor. (FIG. 1-1)

FIGURE 1-1

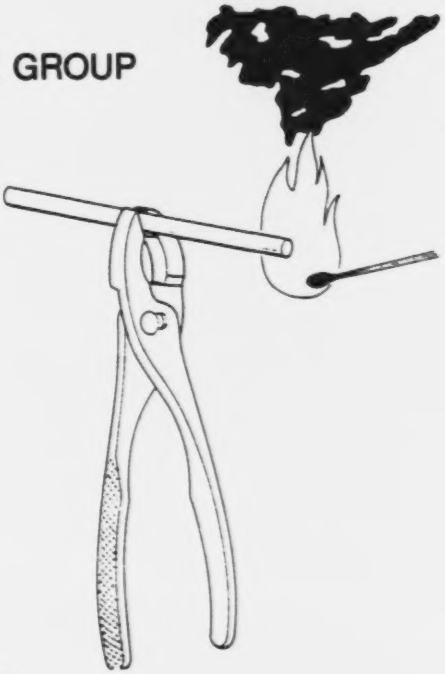


Courtesy of PPG Finishes

b. Polyurethane – Burns with a yellow-orange flame and black smoke. Continues to burn when flame is removed, but the flame sputters. (FIG. 1-2)

FIGURE 1-2

URETHANE GROUP

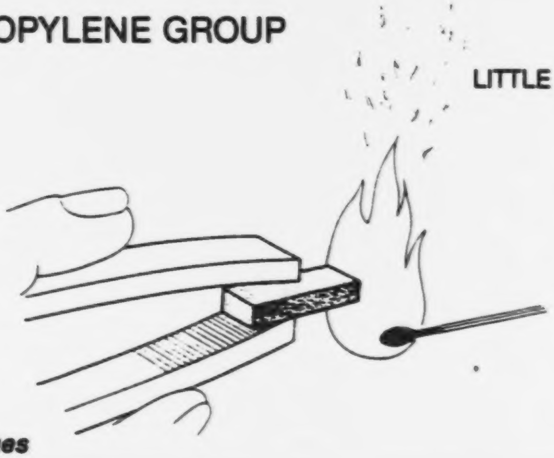


Courtesy of PPG Finishes

c. Polypropylene – Burns with little visible smoke and continues to burn when flame is removed. Floats in water. Has a characteristic odor. (FIG. 1-3)

FIGURE 1-3

POLYPROPYLENE GROUP



Courtesy of PPG Finishes

(NOTE: It is very important to correctly identify Polypropylene because it requires an adhesion promoter for repair and both an adhesion promoter and a Polypropylene primer for refinishing.)

d. Polyvinyl Chloride – Chars and gives off gray smoke. Does not continue to burn after flame is removed. Has a characteristic odor.

(NOTE: One of the reasons the burn test does not always work is that some vehicle plastics are blends of different kinds of plastics. Also the color and smell of the smoke may be interpreted differently by different technicians.)

5. If you suspect the plastic is PVC, then perform the copper wire test.

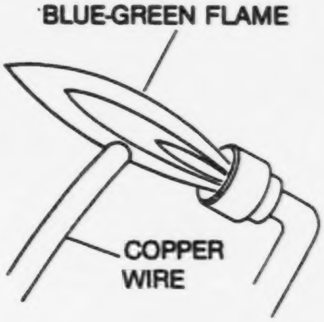
a. Heat a copper wire in a propane or equivalent torch until the wire turns red.

b. Touch the heated wire to the backside or hidden surface of the part so that some plastic stays on the wire.

c. Return the wire with the plastic to the flame and watch for a green, turquoise blue flame, which indicates PVC.

d. If black smoke residue, hanging in the air, is readily visible along with the green flame, then the part is made of soft ABS (ABS/PVC). (FIG. 1-4)

FIGURE 1-4



Courtesy of PPG Finishes

6. One other test will work on polyolefins. If you suspect the plastic is a polyolefin, grind on the plastic in a non-visible area. A polyolefin will melt and smear, instead of grinding smooth and producing dust.

7. Melt test

a. After deciding what the plastic probably is, select a plastic welding rod of that type.

(NOTE: Your instructor will show you how to identify the plastic welding rods available in your shop. The rods are color-coded, but different manufacturers use different color codes.)

b. Clean a small area of the plastic part in the repair area, then rough up the surface with a die grinder, or hand sand with 80-grit paper, to remove the silicon-based coating.

(NOTE: Follow cleaning procedures outlined later in this unit)

c. Heat the end of the rod with either an airless or hot-air welder until it begins to melt, then quickly press the heated end of the rod into the prepared area. If the rod is the correct rod it will stick firmly. If it does not stick, try another type of rod.

(NOTE: Some plastics can be successfully welded or weld-bonded using a welding rod of a different type of plastic. If the rod selected works, it does not matter if it is the same type of plastic. For example, there are no matching rods for many blends of plastics, but a rod that will work can often be found.)

8. Further notes on plastic identification

a. In identifying plastics, is can be helpful to know the appearance and location of the plastic.

b. They may be hard or flexible

c. They may be interior plastics or exterior plastics

d. Common locations of plastics and the most common plastics used in those areas (Table 1-1)

TABLE 1-1

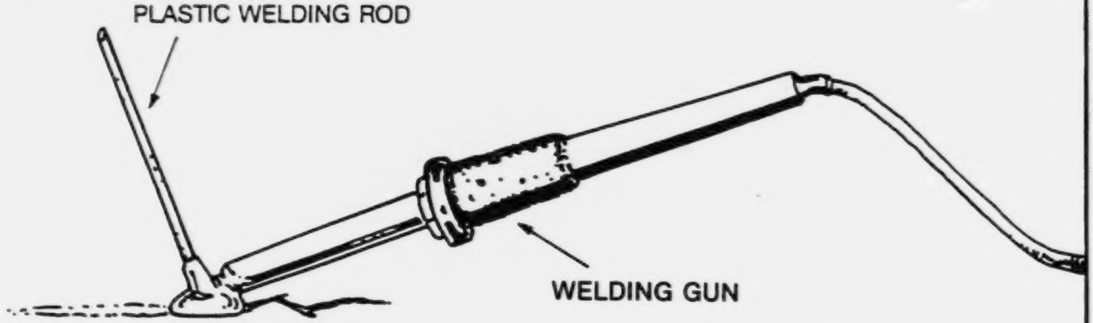
APPEARANCE AND LOCATION	COMMON PLASTIC PANELS FOUND	MOST COMMON PLASTICS USED
Interior hard plastics	Dash panel, Trim panels	ABS, Polypropylene
Underhood hard plastics	Inner fenders, Fan shrouds	ABS, Polypropylene
Interior soft plastics	Dash pads, trim panels	PVC, Vinyl-covered Urethane foam
Exterior hard plastics	Body panels, grilles	Wide variety, mostly thermosetting
Exterior flexible plastics	Bumper or fascia covers	Polyurethanes, (includes RIM) Polyolefins

II. Plastic repair techniques

A. There are five basic repair methods for plastic panels

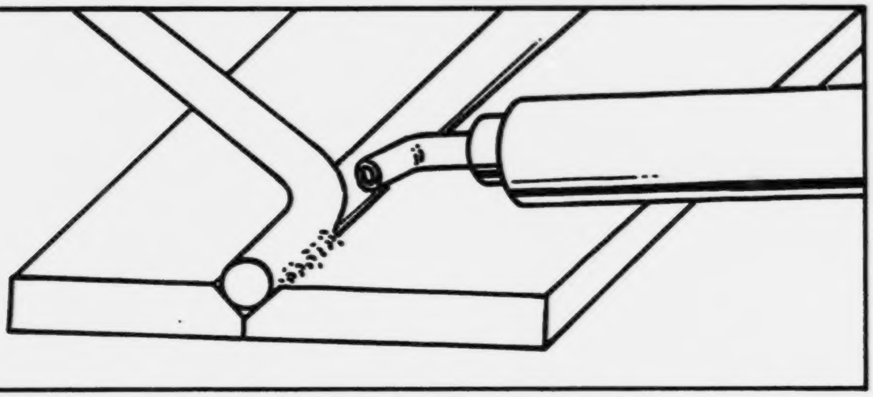
1. Airless plastic welding – Used on many plastics and is the only possible method on some types of thermosetting plastics. (FIG. 1-5)

FIGURE 1-5



2. Hot-air plastic welding – Used on many thermoplastics, but cannot be used on thermosetting plastics. (FIG. 1-6)

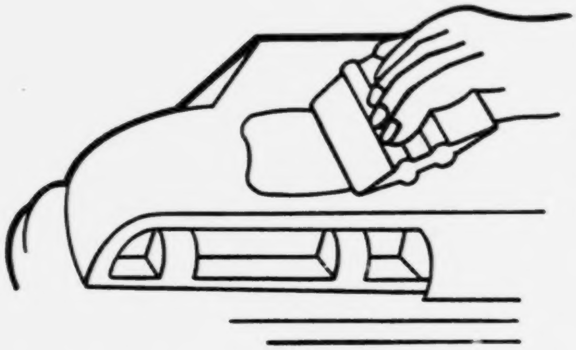
FIGURE 1-6



3. Adhesive fillers – Used on flexible exterior panels (polyurethanes and polyolefins) and also on thermoplastic rubber. (FIG. 1-7)

   *(**Caution:** There is also a hard-setting adhesive filler for use on some hard exterior panels, including PC. Consult manufacturer's recommendations for using hard-setting fillers.)*

FIGURE 1-7



Courtesy of 3M Automotive Division

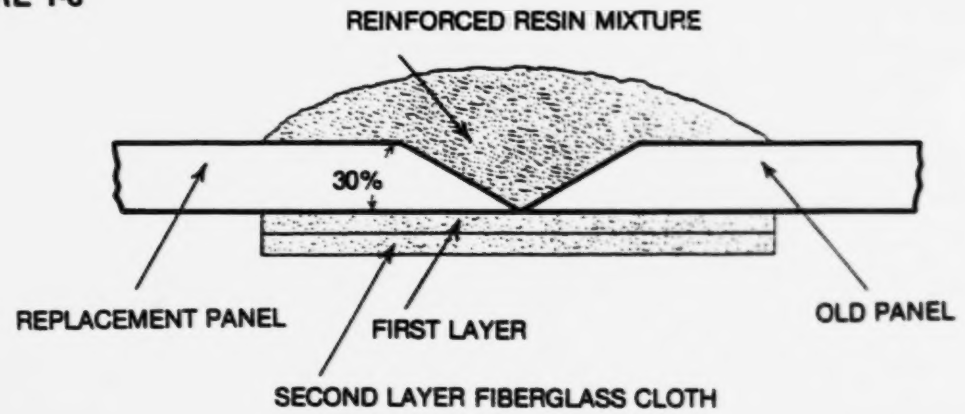
4. Patching compound (liquid vinyl) – Used on soft polyvinyl chloride, including ABS/PVC interior panels and vinyl tops.

   (NOTE: See the unit on vinyl top repair in the Exterior and Interior Trim Module for the method of using liquid vinyl.)

5. Fiberglass repair – Used on fiberglass compounds and also in some situations on hard plastics. (FIG. 1-8)

   (Note: See Unit V, Fiberglass Repair, this Module, for the methods of using fiberglass repair)

FIGURE 1-8


REINFORCED RESIN MIXTURE
30%
REPLACEMENT PANEL
FIRST LAYER
OLD PANEL
SECOND LAYER FIBERGLASS CLOTH

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B. Airless and hot-air plastic welding

1. Airless plastic welding is performed using a special airless plastic welder and special plastic welding rods.

2. For thermoplastics, airless welding performs the same task as hot-air welding-completely fusing the welding rod and base material together.

3. For thermosets, airless welding makes a weld-bond.

4. Airless welding heats a smaller area of the material being welded than a hot-air welder, and the air pressure on a hot-air welder can literally blow some types of plastic away.

5. Airless welding prevents warpage in the case of thin thermoplastics, and prevents the melting of thermosets (which would destroy them). Airless welding also uses a smaller rod (1/8" in diameter verses 3/16" in diameter)

   (NOTE: A 1/8" rod can be used with hot-air welders and should be used if the panel being repaired is less than 3/16" thick.)

6. In welding thermoset plastics, the plastic to be welded is heated just enough to provide a bondable surface and the welding rod is melted into the prepared weld area. The resulting weld has the characteristics of both a weld and an adhesive bond.

7. The techniques for airless welding and hot-air welding vary only slightly.

C. Principles of airless and hot-air plastic welding

1. While all plastic welding equipment is similar, always follow the manufacturer's recommendations for operating the particular gun or guns in your shop.

2. The welding rod selected must be compatible with the base material (but it does not always have to be the same material - use the melt test).

3. Both airless and hot-air welding require the proper selection of the temperature setting on the welder, according to the type of plastic being welded.

4. Learn horizonal welding prior to attempting vertical or overhead welds.

D. Safety precautions

1. Never use a plastic welder in a wet or damp area - it can cause an electric shock.

2. Never use a plastic welder with, or near, oxygen or other flammable gasses.

3. Beware that the welding tip is hot enough to burn your skin if you come into direct contact with it. The air stream from a hot-air welder will not burn you on brief contact, but can burn you if the contact is long enough.

4. Position your head to side of rising fumes as you weld.

5. Use a particle mask whenever doing any sanding or grinding on plastics.

6. Wear safety glasses whenever doing plastic welding, with either heat or adhesives.

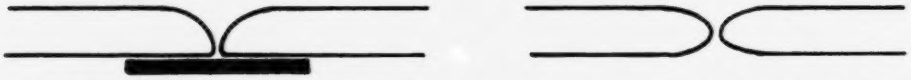
E. Basic welding procedures

1. Part must first be cleaned with soap and water and then plastic cleaner.

   (NOTE: Some interior parts which have been coated with after-market protectants may have to be cleaned several times with plastic cleaner to remove the coating.)

2. A die grinder or similar tool must be used to bevel the weld area. A one-sided weld must have a penetration of 75%. Two-sided welds should be beveled 50% on each side, so the welds touch. If possible, a one-sided weld should be beveled 100% and aluminum tape used to hold the parts for welding. (FIG. 1-9)

FIGURE 1-9



BEVEL FOR ONE-SIDED WELD, USING BACKING STRIP

BEVEL FOR TWO-SIDED WELD

3. The area surrounding the weld should have any paint removed with a low-speed grinder using 60- or 80-grit grinding disc.

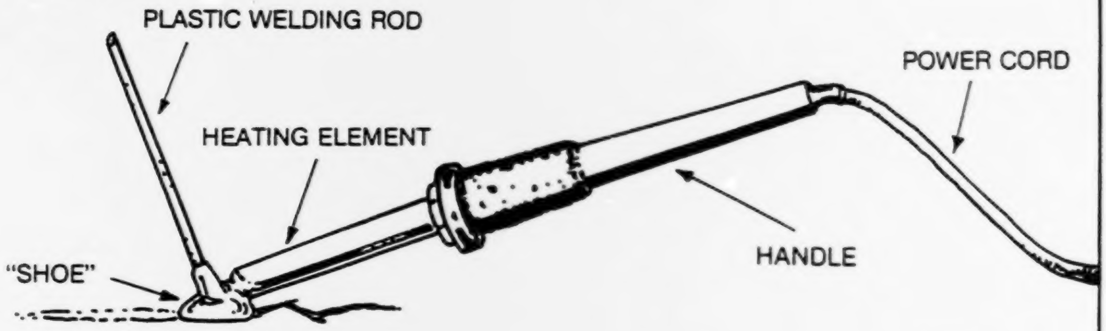
4. The welding heat must be properly set and the welding speed must be properly controlled.

5. Specific techniques for making welds vary according to the type of plastic.

   (NOTE: Since ABS, polypropylene, and polyurethanes are the most common weldable components, the welding techniques covered for in this unit will deal primarily with those plastics. Welding other plastics is similar and once welding ABS, polypropylene and polyurethane is mastered, repair of the other plastics can be easily learned.)

F. Welding gun parts (FIG. 1-10)

FIGURE 1-10



G. Welding ABS

1. In welding ABS the "stitch-tamp" method should be used.

2. The pointed end of the tip is moved slowly into the weld area, forcing the rod into the base material

3. After the area is welded the "shoe" of the welder is used (without a welding rod) to smooth the repaired area

4. The excess is scraped away with a razor blade while the weld is still warm

H. One-sided verses two-sided welds

1. One-sided welds can be used when the back of the part is not accessible, however the two-sided method is required for any high-stress parts.

2. To align broken parts or to align two-sided welds, aluminum body tape should be pressed against the break.

I. Welding dash pads

1. Welding dash pads follows the same basic procedure as welding ABS, except that the vinyl covering over the urethane will have to be repaired with liquid vinyl adhesive (patching compound).

2. Consult the Vinyl Top Repair Unit in Module 5, "Exterior and Interior Trim" for PVC repair.

J. Adhesive repair

1. Either two-part epoxy or two-part urethane adhesives can be used to repair flexible exterior panels, including both thermoplastic and thermoset polyurethane panels and also polyolefin panels

2. Adhesive repair will mainly be used to repair bumper covers and soft fascias, which are often made of urethanes or polyolefins

3. The procedure is the same for repairing urethanes and polyolefins except that polyolefins require the use of an adhesion promoter prior to each adhesive application

4. If repairing a tear or cut that goes all the way through the part a fiberglass mat reinforcement should be used on the back side to prevent the material from falling through.

   (NOTE: If the tear or hole is small, a piece of aluminum tape can be used to hold the material in place, then removed after the material has set up.)

5. To tell if the material is a urethane or polyolefin sand a small portion of the repaired area with a grinder. A urethane will sand normally, showing sanding dust and a smooth area, while a polyolefin will melt and smear.

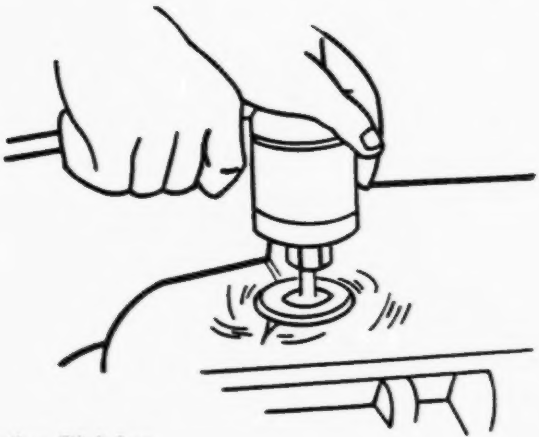
6. Basic procedure for adhesive repair

   (NOTE: If repairing a polyolefin, apply adhesion promoter just before each filler application.)

   a. Clean area.

   b. Grind with 36-grit disc. (FIG. 1-11)

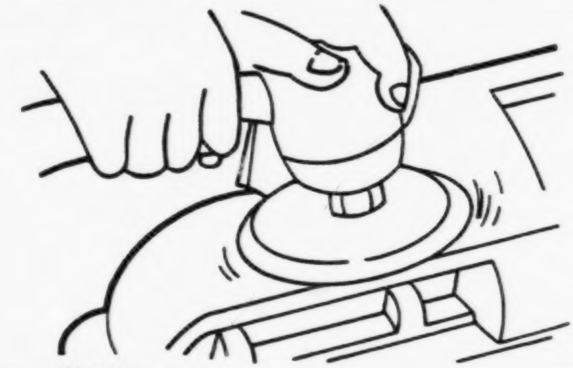
FIGURE 1-11



Courtesy of 3M Automotive Division

c. Featheredge with 180-grit paper. (FIG. 1-12)

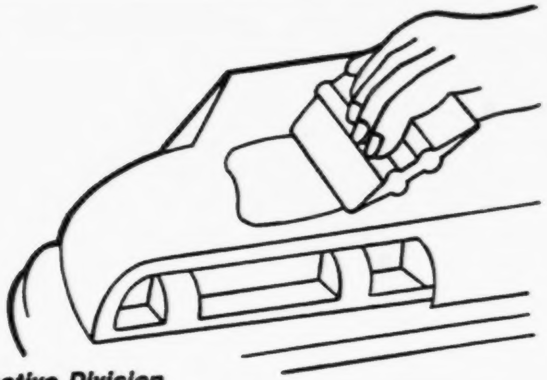
FIGURE 1-12



Courtesy of 3M Automotive Division

d. Apply filler (apply adhesion promoter first if a polyolefin). (FIG. 1-13)

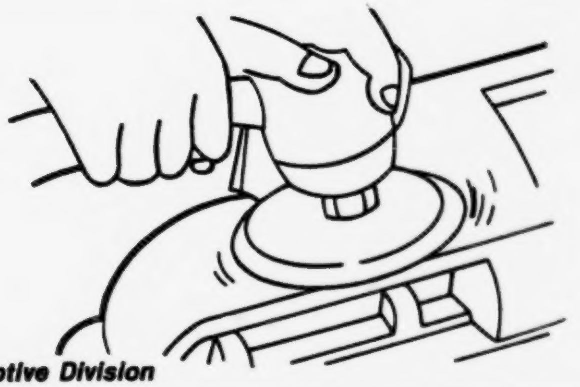
FIGURE 1-13



Courtesy of 3M Automotive Division

e. Sand with 180 and 240. (FIG. 1-14)

FIGURE 1-14



Courtesy of 3M Automotive Division

f. Apply additional filler (apply adhesion promoter first if a polyolefin).

g. Sand with 320.

h. Apply flexible sealer.

i. Scuff with 320.

j. Apply color.

K. Plastic refinishing techniques

1. Re-texturing

(NOTE: A polypropylene primer is necessary when re-texturing or refinishing polypropylene. When working with vinyl, refer to the unit on Vinyl Top Repair Exterior and Interior Trim, Module 5.)

a. Re-texturing interior plastic parts, particularly dash, door panels, arms rests, etc., is an important part of refinishing.

b. After plastic repair procedures, the surface of the repaired area is smooth and will not match the texture of the surrounding area.

c. Re-texturing the area involves the use of a sprayable texture material.

d. In trying to match the texture, only the coarseness of the texture needs to be matched. The coarseness of the texture of the sprayed material depends on how much it is thinned. Using no thinner at all produces a very coarse grain, while the more thinner is used, the finer the texture.

e. After a thorough cleaning, spray the texture material directly to the repaired area, following the texture material manufacturer's recommendations.

f. Many coats may be necessary the achieve the proper build up

(NOTE: Always spray a dry coat of the material, never a wet coat)

g. Once the immediate repair area matches the original texture, then blend the texture material out onto the undamaged surface surrounding the repair.

h. After applying the texture material, nib sand the area with 220-grit paper.

i. Always blow the area clean when preparing for refinishing. Do not use any type of cleaner.

2. Refinishing

a. Following the refinishing procedures outlined in the Paint and Refinishing Module. Always consult manufacturer's recommendations for painting any type of plastic.

b. In general, all exterior applications will require a primer, while interior applications will not (the exception is polypropylene, which requires a polypropylene primer in all applications).

c. Polyolefins require special adhesion promoters for refinishing and a special topcoat system. Consult paint supplier for recommendations.

d. ABS can be painted with a standard lacquer system.

e. Vinyl (ABS/PVC and PVC) must be painted with a vinyl paint system. (See Exterior and Interior Trim, Module 5, Vinyl Top Repair Unit.)

f. Nylon can be painted with a standard lacquer system.

g. All polyurethanes, plus thermoplastic rubber, require the use of a flexible lacquer or enamel system.

UNIT IV

JOB SHEET #1, LESSON ONE

CLEAN PLASTIC EXTERIOR AND INTERIOR SURFACES

Equipment:

Mild detergent and water solution
Clean, lint-free white rags
Plastic cleaner

Procedure:

		Evaluation:			
		3	**2**	**1**	**N**
1.	Wash panel with detergent solution.	___	___	___	___
2.	Clean panel with plastic cleaner.	___	___	___	___
	(**CAUTION:** *Use only an approved plastic cleaner. Do not use other solvents.)*				
3.	Repeat application of plastic cleaner as often as needed to remove any aftermarket coatings.	___	___	___	___
	(**CAUTION:** *Do not reapply any type of cleaner after repair work begins.)*				
	Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency H3 "Clean exterior and interior surfaces.")

UNIT IV

JOB SHEET #2, LESSON ONE

IDENTIFY PLASTIC TYPE AND ANALYZE DAMAGE TO PLASTIC PANELS

Equipment:

Mild detergent and water solution
Clean, lint-free white rags
Plastic cleaner
Combination pliers
Sharp knife
Matches
Selection of plastic welding rods

Procedure:	**Evaluation:** 3	2	1	N
1. On a non-visible portion of the panel, select a small area and clean surface by performing Job Sheet #1.				
2. Using a sharp knife remove a silver of the plastic part from the cleaned portion of the panel.				
3. Holding the silver with the pliers burn the end of the silver by holding a match to it. Observe the results and classify the plastic type.				
4. Based on the observations from step 3, select a welding rod of proper type, rough up the test portion of the surface and melt the tip of the rod to the prepared portion of the panel.				
5. Repeat step 4, if needed, until a compatible welding rod is found.				
6. Based on your observations from steps 3-5 determine type of plastic, and repair method (on-car, off-car, single-sided, double-sided.)				
7. Based on your knowledge of plastic repair, determine if the panel can be properly and economically repaired.				
Average of above evaluations*				

(*This average is evaluation for Competency H2 "Analyze damage," and Competency H1 "Identify plastic types.")

UNIT IV

JOB SHEET #3, LESSON ONE

PERFORM TWO-SIDED AIRLESS PLASTIC WELD ON ABS

Equipment:

Detached ABS panel with damage
Airless plastic welder
Proper welding rod(s)
Aluminum tape
Mild detergent and water solution
Clean, lint-free white rags
Plastic cleaner
Die grinder or similar tool
Slow-speed grinder

Procedure:	**Evaluation:** 3	2	1	N
1. Clean panel by performing Job Sheet #1.	___	___	___	___
2. Align the crack or tear by pressing aluminum body tape to the front side of the panel.	___	___	___	___
3. Use die grinder or similar tool to grind a groove along crack or tear. First grind groove 50% of way through back side of panel, beveling edges to a 45 degree angle.	___	___	___	___
4. Using stitch-tamp method, weld back side of panel. Place the shoe part of the tip over the V-groove and do not move it until the rod starts to flow out around the shoe. Then move the shoe slowly, back and forth as needed across the groove and down the seam, stitch-tamping the rod into the groove.	___	___	___	___
5. Wipe a damp sponge over the weld to cool it, then remove the tape from the front.	___	___	___	___
6. Use die grinder or similar tool to grind a groove along a crack or tear. Grind groove 50% of way through front side of panel and into back-side weld, beveling edges to a 45-degree angle.	___	___	___	___

Procedure:

Evaluation:
3 2 1 N

7. Using stitch-tamp method, weld front side of panel. Place the shoe part of the tip over the V-groove and do not move it until the rod starts to flow out around the shoe. Then move the shoe slowly, back and forth as needed across the groove and down the seam, stitch-tamping the rod into the groove. ___ ___ ___ ___

8. Use the flat shoe of the welder to smooth the repaired area, then use a razor blade or a low-speed grinder with an 80-grit disc to smooth weld. ___ ___ ___ ___

9. Test weld by bending against weld, first one way and then the other. Weld should show good penetration, and no signs of cracking or pulling apart. ___ ___ ___ ___

10. Scuff sand area with 320-grit to prepare for refinishing. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for Competency H5 "Perform airless plastic welding.")

UNIT IV

JOB SHEET #4, LESSON ONE

PERFORM CHEMICAL PLASTIC WELDING ON A URETHANE PLASTIC BUMPER

Equipment:

Flexible urethane soft bumper cover with puncture or tear
Detergent and water solution
Wax and grease remover with dampened cloth
Random orbital sander with 180-grit disc and 320-grit disc
Die grinder or equivalent with 2" or 3" 50-grit disc
Non-porous mixing surface (plastic, glass or metal)
Structural adhesive
Mixing paddle for adhesive
Squeegee or plastic spreader
Curved-tooth body file
Sanding block and 220-grit paper

Procedure:

Evaluation:
3 2 1 N

1. Clean repair area with detergent and water solution and wipe dry. Then clean area with wax and grease remover, applied with a water-dampened cloth. Wipe dry. ____ ____ ____ ____

2. Using a random orbital sander with a 180-grit disc, remove paint in the area of the repair and the surrounding area. ____ ____ ____ ____

   (Remove paint as far out as need be to avoid adhesive-repair area from coming into contact with paint.)

3. Use die grinder or equivalent with 2" or 3" 50-grit disc to enlarge puncture, removing all foreign material and creating at least a 1" taper around the gouge area. ____ ____ ____ ____

4. Use blow gun to remove all dust and loose particles. ____ ____ ____ ____

5. If hole through material is small, apply aluminum tape to back of panel, using squeegee or paint paddle. If hole is large, fiberglass repair material may have to be placed over backside of hole. ____ ____ ____ ____

   (NOTE: See Unit V on Fiberglass Repair for procedures on mixing fiberglass resin and filler material.)

Procedure: **Evaluation:**
3 2 1 N

6. On non-porous surface, mix adhesive following manufacturer's recommendations, noting the temperature of the adhesive and the surface. Apply material with a squeegee or plastic spreader. First apply a thin coat over entire area, then build up material to a level above the desired contour. ___ ___ ___ ___

   (NOTE: Unlike plastic filler for metal repair, the adhesive material does not have to be sanded between coats.)

7. Allow mixture to cure 20 to 30 minutes. If needed, add more material to low areas, otherwise begin shaping filler with a curved-tooth body file. ___ ___ ___ ___

8. Block sand with 220-grit paper, bringing repair into proper contour. ___ ___ ___ ___

9. Featheredge with random orbital sander and 320-grit disc and remove aluminum tape, if used, from back of panel. ___ ___ ___ ___

10. If low spots or pinholes exist, apply flexible parts repair material according to recommendations, then block sand with 220-grit and featheredge with 320-grit disc on orbital sander. ___ ___ ___ ___

    (NOTE: Refinish using flexible paint system, following procedures outlined Paint and Refinishing, Module 4.)

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for Competency H4 "Perform chemical plastic welding," Competency K4 "Repair soft fascia covers," and Competency H6 "Repair plastic with chemical fillers.")

(NOTE: Chemical filler is the material used to fill imperfections in the surface of the repaired plastic.)

UNIT IV

JOB SHEET #5, LESSON ONE

REPAIR VINYL-CLAD URETHANE FOAM DASH

Equipment:

Airless plastic welder
Urethane welding rod(s)
Mild detergent and water solution
Clean, lint-free white rags
Plastic cleaner
Die grinder or similar tool
Slow-speed grinder
Non-porous mixing surface (plastic, glass or metal)
Vinyl repair kit adhesive
Mixing paddle for adhesive
Squeegee or plastic spreader
Sanding block and 40-grit, 80-grit and 180-grit paper
Texture material or vinyl die, according grain needed

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
1. Set the welder temperature for urethane then clean the repair area by performing Job Sheet #1.	___	___	___	___
2. Examine the vinyl material covering the Urethane. If there are torn edges, cut away. If brittle, soften with a heat gun.	___	___	___	___
3. Use the die grinder or similar tool to cut at least a 1/4" groove in the Urethane, beveling the edges; then rough up edges on both sides for 1/4" or more.	___	___	___	___
4. Rotate the welder so that the shoe is up and the melt tube is down, then deposit welding rod slowly until repair area is filled with material flush to the surrounding surface.	___	___	___	___
(NOTE: Start filling at the bottom of the groove and work up.)				
5. Use the shoe to smooth out the repaired area, feathering the material at least 1/4 inch beyond the beveled edges.	___	___	___	___
6. Use a die grinder with a drum sander attachment to remove remaining excess welding rod, then rough up the vinyl at least 2" beyond the repair area.	___	___	___	___

Procedure:	**Evaluation:** 3	2	1	N
7. Follow manufacturer's recommendations for mixing and applying vinyl filler. Apply to entire repair area.	___	___	___	___
8. After filler cures, sand to contour. Start with 40-grit, then 80-grit, then 180-grit. If filler is sanded through apply thin coat, cure and sand again.	___	___	___	___
9. Re-texture by performing Job Sheet #6, or replace grain using a vinyl die. (See Exterior and Interior Trim, Module 5, the unit on Vinyl Top Repair for using a vinyl die.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is half of the evaluation for Competency H7 "Repair and retexture plastic dash." The other half is from Job Sheet #6.)

UNIT IV

JOB SHEET #6, LESSON ONE

RE-TEXTURE PLASTIC DASH PANEL

Equipment:

Plastic interior component which has been plastic welded
Texture material
Spray gun
Proper thinner/reducer
Adhesion promoter, if required
Appropriate sandpaper
Safety goggles
Rubber gloves
Recommended respirator

Procedure:	**Evaluation:** 3	2	1	N
1. Scuff sand area with recommended sandpaper.	___	___	___	___
2. Put on appropriate safety equipment, mask adjacent panels, and apply texture material following manufacturer's recommendations.	___	___	___	___
3. When texture match is achieved, blend repair area into unrepaired area.	___	___	___	___
4. Allow texture material to dry, then scuff sand with recommended sandpaper to flatten the sprayed texture.	___	___	___	___
5. Refinish component with appropriate matching, flexible paint, if required.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is half the evaluation for Competency H7, "Repair and re-texture plastic dash." The other half is from Job Sheet #5.)

MODULE: PANEL REPAIRS

UNIT IV: PLASTIC REPAIR

UNIT IV TEST

PART I—PLASTIC IDENTIFICATION

I. Select the best answer from among the five choices listed.

____ 1. The type of plastic which cannot be melted without destroying it is: (a) Thermoplastic (b) Thermosetting plastic, (c) Polyolefin (d) Polyurethane, (e) Polyvinyl Chloride.

____ 2. The type of plastic which can be heated and reshaped over and over is: (a) Thermoplastic (b) Thermosetting plastic, (c) Polyolefin (d) Polyurethane, (e) Polyester.

____ 3. One type of plastic which is used to make fiberglass is: (a) Thermoplastic (b) Thermosetting plastic, (c) Polyolefin (d) Polyurethane, (e) Polyester.

____ 4. The type of plastic which requires an adhesion promoter for repairs is: (a) Thermoplastic (b) Thermosetting plastic, (c) Polyolefin (d) Polyurethane, (e) Polyester.

____ 5. The two most common thermoplastics in vehicle parts are: (a) PVC and Polyolefin, (b) Polyolefin and ABS, (c) ABS and Polypropylene, (d) Polypropylene and Urethane, (e) Urethane and PVC.

____ 6. The most common thermosetting plastic in vehicle parts is: (a) ABS, (b) TPUR, (c) PUR, (d) PP, (e) PVC.

____ 7. The type of plastic which can be recognized because it melts and smears when sanded is: (a) Polypropylene, (b) Polyvinyl Chloride, (c) Polyolefin, (d) Polyurethane, (e) Polyester.

____ 8. Which of the following is NOT one of the ways to determine a type of plastic? (a) Use shop manual, (b) See if code stamped on part, (c) Call parts supplier, (d) Perform melt test, (e) Check appearance and texture.

____ 9. Dash pads and trim panels are likely to be made from which of the following plastics: (a) PVC and PVC-covered urethane foam, (b) PP and PVC, (c) ABS and PP, (d) TPO and PUR, (e) SAN and T/P.

____10. Bumper covers or soft fascias are likely to be made from which of the following plastics: (a) PVC and PVC-covered urethane foam, (b) PP and PVC, (c) ABS and PP, (d) TPO and PUR, (e) SAN and T/P.

____11. Underhood hard plastics are likely to be made from which of the following plastics: (a) PVC and PVC-covered urethane foam, (b) PP and PVC, (c) ABS and PP, (d) TPO and PUR, (e) SAN and T/P.

II. Match the type of plastic in the left column with the proper identification from the burn test in the right column

_____12. ABS

_____13. PUR

_____14. PP

_____15. PVC

A. Burns blue-green when melted on copper wire

B. Yellow-orange flame and black smoke

C. Melts like wax

D. Burns with little smoke

E. Burns with thick, black sooty smoke

(NOTE: Completion of this portion of the unit test with a minimum score of ____ is necessary for the student to receive an evaluation for Competency H1 "Identify plastic types.")

PART II–PLASTIC REPAIR METHODS

I. Select the best answer from among the five choices listed.

____16. The use of plastic parts has increased in vehicles due primarily to their: (a) strength, (b) cost, (c) weight, (d) appearance, (e) repairability.

____17. The plastic repair method which makes a weld-bond on thermosetting plastics is: (a) adhesive repair, (b) hot-air welding, (c) airless welding, (d) fiberglass repair, (e) patching compound.

____18. The plastic repair method which uses forced air to weld plastic is: (a) adhesive repair, (b) hot-air welding, (c) airless welding, (d) fiberglass repair, (e) patching compound.

____19. A plastic repair method which is used on flexible exterior panels made of Polyurethane and Polyolefin is: (a) adhesive repair, (b) hot-air welding, (c) plastic filler, (d) fiberglass repair, (e) patching compound.

____20. The plastic repair method used on PVC and ABS/PVC is: (a) adhesive repair, (b) hot-air welding, (c) airless welding, (d) fiberglass repair, (e) patching compound.

____21. The plastic repair method used on some hard plastics, as well as Polyester and Epoxy is: (a) adhesive repair, (b) hot-air welding, (c) airless welding, (d) fiberglass repair, (e) patching compound.

____22. Both airless and hot-air welding require the correct setting of the: (a) heat control, (b) speed control, (c) depth control, (d) feed control, (e) all of the above.

____23. In welding plastics you must first clean the plastic with: (a) detergent, then a solvent, (b) a solvent, then a detergent, (c) detergent, then a plastic cleaner, (d) a plastic cleaner, then detergent, (e) a plastic cleaner, then a solvent.

____24. A one-sided weld should be grooved to a penetration of at least: (a) 25%, (b) 50%, (c) 75%, (d) 100%, (e) none of the above.

____25. A two-sided weld should be grooved on each side to a penetration of: (a) 25%, (b) 50%, (c) 75%, (d) 100%, (e) none of the above.

____26. In welding ABS you must use: (a) an adhesion promoter, (b) an airless welder, (c) the stitch-tamp method, (d) adhesive repair, (e) a universal welding rod.

____27. Two-part Epoxy or two-part Urethane components are used in: (a) an airless welder, (b) a hot-air welder, (c) the stitch-tamp method, (d) adhesive repair, (e) quick repair.

____28. In re-texturing a component, the thing to be most concerned about the grain is its: (a) flexibility, (b) shape, (c) coarseness, (d) height, (e) type of material.

II. Mark a T if the statement is true and an F if the statement is false.

____29. You should not use a plastic welder in a wet or damp area.

____30. For best results, use pure oxygen to make a plastic weld.

____31. The welding tip is hot enough to burn you.

____32. The hot air from a hot-air welder can burn you if it accidentally comes into contact with your skin for more than a brief period.

____33. You should position your head to the side of rising fumes when plastic welding.

____34. Whenever sanding or grinding on plastic you should use a particle mask.

____35. It is not necessary to wear safety glasses when repairing plastic.

(NOTE: Completion of this portion of the Unit Test with a minimum score of ____ is necessary for the student to receive evaluations on the Job Sheets in this Unit.)

ANSWERS TO UNIT IV TEST

PART I.

1. B
2. A
3. E
4. C
5. C
6. C
7. C
8. E
9. A
10. D
11. C

12. E
13. B
14. D
15. A

PART II.

16. C
17. C
18. B
19. A
20. E
21. D
22. A
23. C
24. C
25. B
26. C
27. D
28. C

29. T
30. F
31. T
32. T
33. T
34. T
35. F

MODULE: PANEL REPAIRS

UNIT V: FIBERGLASS PANEL REPAIR

UNIT OBJECTIVE

After completion of this unit, the student should be able to analyze damage to fiberglass panels, and be able to reconstruct and section fiberglass panels. This knowledge will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

Lesson 1: I. Identify fiberglass construction, repair, and safety (Competencies I1-I5, Unit IV test)

II. Demonstrate the ability to:

- a. Analyze damage (Competency I2, Assignment Sheet #1)
- b. Clean exterior and interior surfaces (Competency I3, Job Sheet #1)
- c. Reconstruct fiberglass panels (Competency I4, Job Sheet #2)
- d. Section fiberglass panels (Competency I5, Job Sheet #3)

MODULE: PANEL REPAIRS

UNIT V: FIBERGLASS PANEL REPAIR

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

   1. Lesson 1: Repairing Fiberglass Panels

      a. Information outline

      b. Assignment Sheet #1: Analyze damage

      c. Job sheets

         JS # 1: Clean exterior and interior surfaces
         JS # 2: Reconstruct fiberglass panels
         JS # 3: Section fiberglass panels

      d. Transparency masters

         TM#1: Fiberglass repair
         TM#2: Fiberglass repair
         TM#3: Fiberglass repair joint reinforcement
         TM#4: Fiberglass joint repair procedure

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Safety cannot be overemphasized in working with fiberglass. Even if students do not perform fiberglass repair, all students should be made aware of the safety procedures.

REFERENCES USED IN WRITING THIS UNIT

1. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

2. Czapskie, George S., et. al. *Auto Body Repair.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1977.

3. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

4. Taylor, Don and Hofer, Larry. *Paint and Body Handbook.* HPBooks, Inc., Tucson, AZ. 1984.

5. Walker, Susan, and VanWinkle, James. *Automotive Body Refinisher.* Curriculum & Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education. Stillwater, OK. 1986.

MODULE: PANEL REPAIRS

UNIT V: FIBERGLASS PANELS

LESSON ONE: REPAIRING FIBERGLASS PANELS

I. **Fiberglass construction and repair**

  A. Fiberglass parts are made from pre-formed fiber components and fiberglass mats which are fused together with polyester or epoxy resin.

  B. The resin hardens when a catalyst is added, producing a very strong bond which holds the parts securely together.

  C. Advantages of fiberglass

    1. A fiberglass body is very durable.

    2. Fiberglass will not rust.

    3. Fiberglass is light in weight.

    4. Fiberglass never produces a rattle.

    5. Fiberglass bodies do not absorb impact in an ever-widening area as with metal bodies. In the event of an accident, the damage tends to be localized, close to the point of impact.

  D. Disadvantage of fiberglass

    1. Fiberglass will usually crack, chip, or shatter upon impact. Because of this characteristic, fiberglass bodies must be very well reinforced when they are built and when they are repaired.

  E. Replacing panels on a vehicle with fiberglass panels

    1. Replacing panels on the fiberglass body is quite different from replacing panels on the metal body.

    2. Often a small section can be easily replaced because of localized damage.

      a. Sometimes the piece of panel which has broken out can be used in the repair, providing it has been saved.

      b. It is seldom necessary to replace a whole panel unless major damage has occurred.

  F. Panel alignment

    1. It is important to be certain that panels are perfectly aligned whenever working on a fiberglass body.

    2. These panels cannot be shifted as is the case for metal panels.

    3. After installation, fiberglass panels cannot be jacked into alignment without causing damage.

G. Procedure for repair of fiberglass panels

1. Analyze the extent of damage and decide on the repair procedure most suitable for the job at hand.
2. Determine the damaged areas to be removed.
3. Prepare surface for filling.
4. Fill damaged area with resin and glass.
5. Allow catalyzed resin to harden and cure.
6. Sand repair area to its proper contour and refinish.

H. Safety Precautions

1. Fiberglass is made from molten glass which has been drawn out into tiny thread-like fibers.
2. When these fibers are worked with a grinder or sander, they tend to break up into millions of small particles of glass.
3. These particles, if inhaled, can cause respiratory illness.
4. Fiberglass particles which settle on unprotected parts of the body can cause a serious skin irritation.
5. For the above reasons YOU MUST wear a respirator, face shield, and safety glasses and buttoned up collar and shirt sleeves, with elastic or rubber bands around the cuffs, whenever grinding or sanding fiberglass.
6. In fiberglass repair, you will be using epoxy resin, a substance which can also cause skin irritation if safety rules are not strictly followed.
    a. Always wear rubber gloves when handling resin or fiberglass.
    b. Resin mixtures are very toxic and should be used only in well-ventilated areas.
    c. The mixing of resin and hardener causes a chemical reaction which produces heat. The heat buildup could cause a fire. Keep a bucket of water handy for disposal of leftover materials.
7. Some fiberglass resin components can cause blindness if they get into your eye.
    a. Always wear safety goggles when mixing fiberglass resins.
    b. If any fiberglass resin gets into your eye you must flush the eye with water immediately and seek medical help immediately.
8. All tools should be cleaned immediately after use with lacquer thinner, methyl alcohol, or a solution designed for use with fiberglass.

ASSIGNMENT SHEET #1, LESSON ONE

ANALYZE DAMAGE

(NOTE: To successfully complete this assignment sheet, several examples of damage to fiberglass panels should be available. Three are recommended. The student should examine the panels and describe the damage and the proper method of the repair. Completion of job sheet to instructor's satisfaction is the student's final evaluation for competency I2 "Analyze damage.")

EXAMPLE #1:

Describe damage: ______________________________

Describe repair method: ______________________________

EXAMPLE #2:

Describe damage: ______________________________

Describe repair method: ______________________________

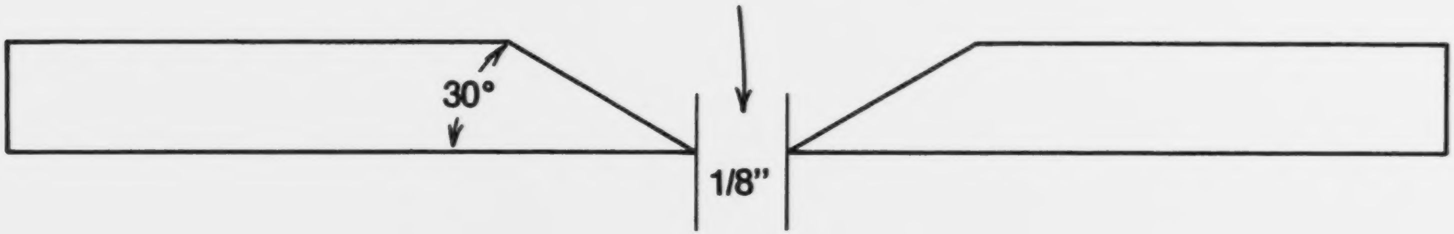
EXAMPLE #3:

Describe damage: ______________________________

Describe repair method: ______________________________

Fiberglass Repair I

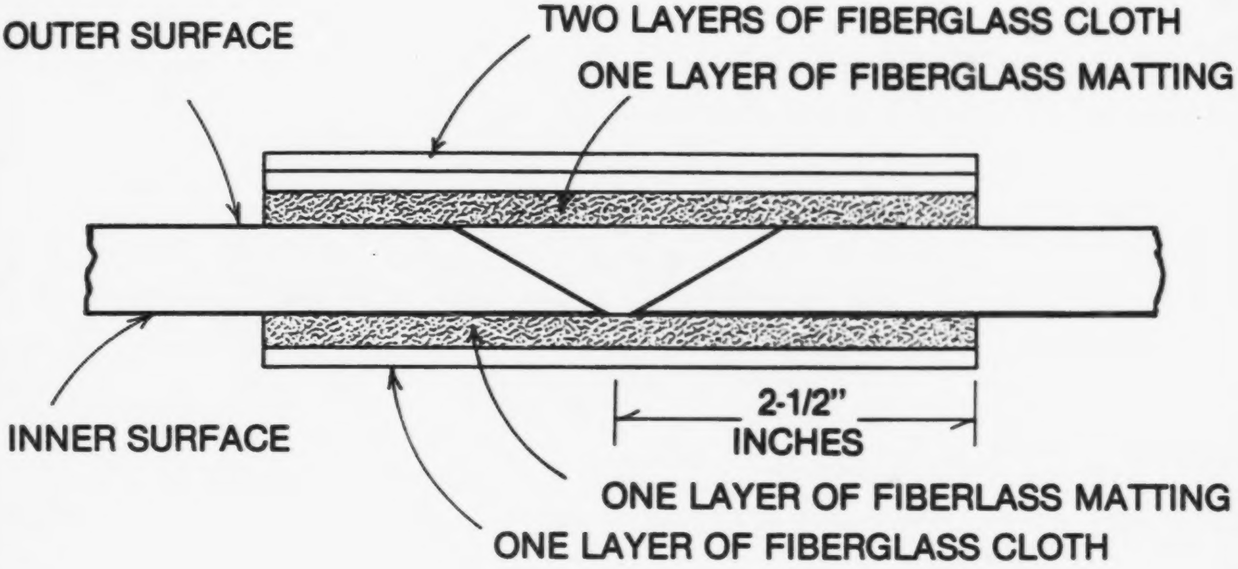
ALLOWED GAP BETWEEN EDGES

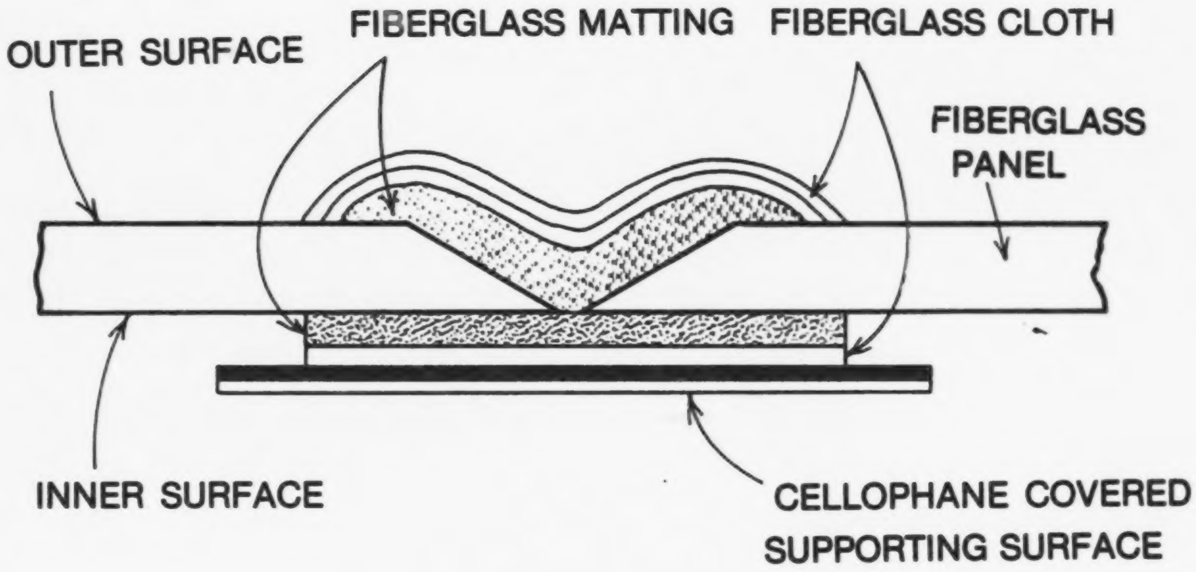


BEVELED BREAK IN FIBERGLASS PANEL

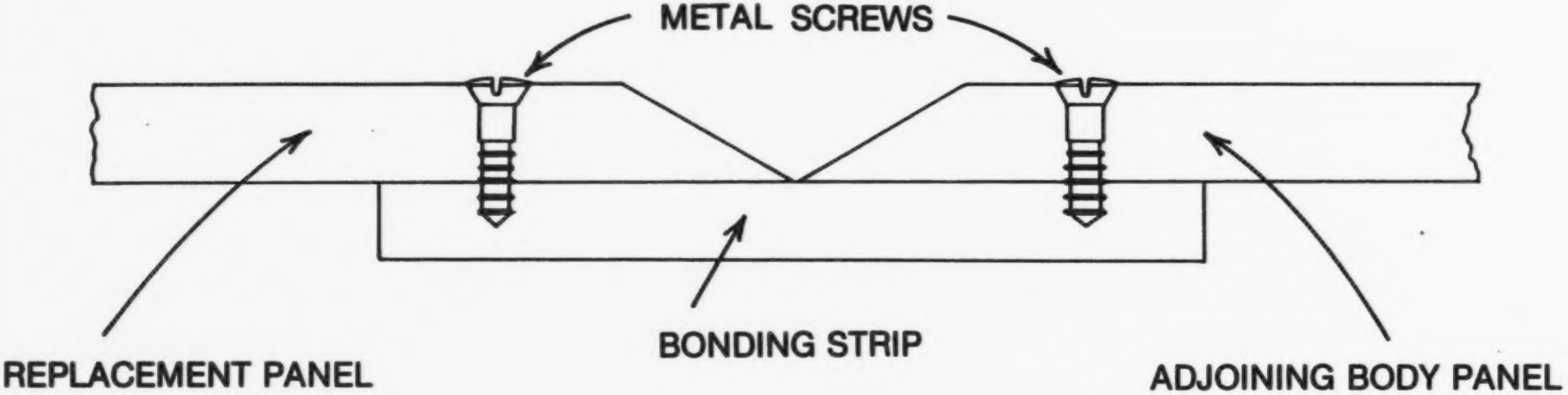
TM 1

Fiberglass Repair II


OUTER SURFACE
TWO LAYERS OF FIBERGLASS CLOTH
ONE LAYER OF FIBERGLASS MATTING
INNER SURFACE
2-1/2" INCHES
ONE LAYER OF FIBERLASS MATTING
ONE LAYER OF FIBERGLASS CLOTH


OUTER SURFACE
FIBERGLASS MATTING
FIBERGLASS CLOTH
FIBERGLASS PANEL
INNER SURFACE
CELLOPHANE COVERED SUPPORTING SURFACE

Fiberglass Repair Joint Reinforcement

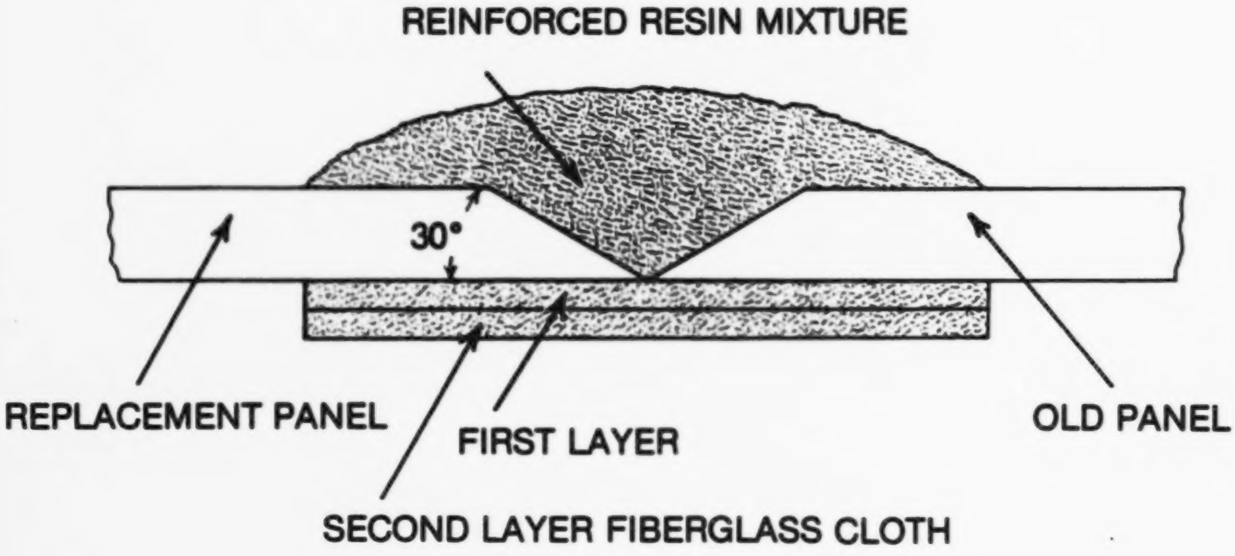

METAL SCREWS
REPLACEMENT PANEL
BONDING STRIP
ADJOINING BODY PANEL

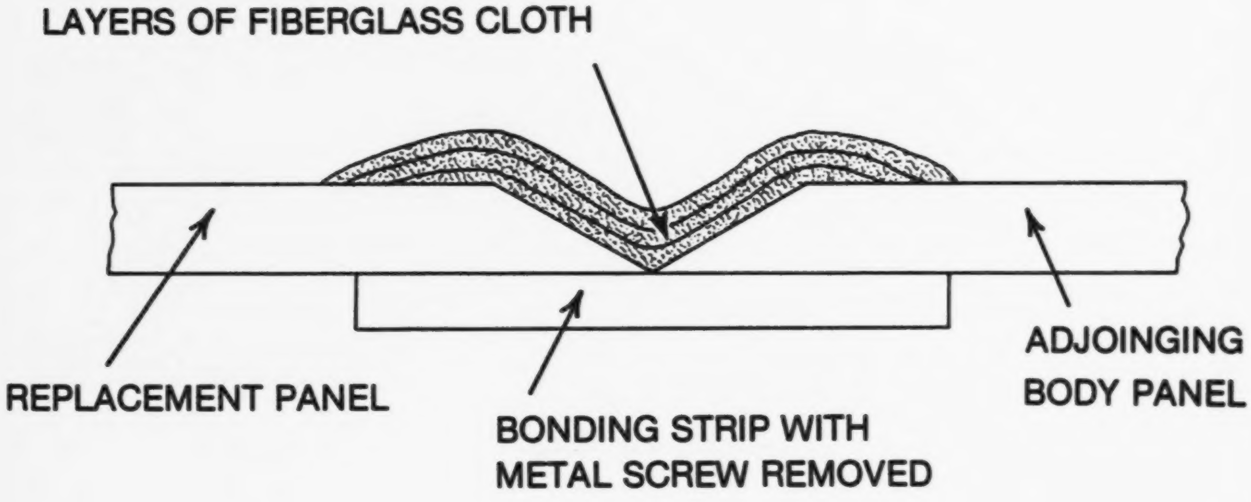
542

543

TM 3

Fiberglass Joint Repair Procedure


REINFORCED RESIN MIXTURE
30°
REPLACEMENT PANEL
FIRST LAYER
OLD PANEL
SECOND LAYER FIBERGLASS CLOTH


LAYERS OF FIBERGLASS CLOTH
REPLACEMENT PANEL
BONDING STRIP WITH METAL SCREW REMOVED
ADJOINGING BODY PANEL

UNIT V

JOB SHEET #1, LESSON ONE

CLEAN EXTERIOR AND INTERIOR SURFACES

Equipment:

Vehicle with fiberglass damage
Water and detergent
Wax and grease remover
Grinder or sander
Safety glasses and face shield
Gloves
Approved respirator

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
1. Wash damaged panel with detergent and water.				
2. Thoroughly clean the outer and inner surfaces around the damaged area with wax and grease remover.				
3. Remove any loose fiberglass from the damaged area.				
4. Grind or sand off the paint and primer to expose the base fiberglass material 2-3 inches beyond the damaged area. Grind or sand both the outside and inside surfaces, if possible. Bevel the edges of the hole.				
Average of above evaluations*				

(*This average is the evaluation for Competency I3 "Prepare exterior and interior surfaces," and will become a part of Job Sheets #2 and #3, this lesson.)

UNIT V

JOB SHEET #2, LESSON ONE

RECONSTRUCT FIBERGLASS PANELS

Equipment:

Vehicle with fiberglass damage
(NOTE: Vehicle must have all pieces salvaged.)
Water and detergent
Wax and grease remover
Grinder or sander
Fiberglass repair kit
Safety glasses and face shield
Gloves
Approved respirator

Procedure:

	Evaluation: 3	2	1	N
1. Perform Job Sheet #1.	___	___	___	___
(NOTE: Working from the backside, remove dirt from all the pieces and from the edges of the main structure.)				
2. Observing safety precautions, use a hacksaw blade or power hacksaw to cut away jagged edges.	___	___	___	___
3. Find any piece that mates to the main structure and clamp the piece into place on the main structure with gripping pliers or clamps.	___	___	___	___
4. Smear a coating of resin/hardener mixture on both the main structure and the piece, building a resin "bridge" over the crack.	___	___	___	___
5. Repeat this process with each of the pieces until all of the broken fragments have been glued together. This will form one rough, basic structure.	___	___	___	___
6. Next, quickly check the assembly for rigidity. It will usually need more resin to reinforce the back side of the panel. In any case, most of the broken edges will be visible on the outside surface.	___	___	___	___

Procedure:

Evaluation:
3 2 1 N

7. With a rough disc, grind the whole outer surface, removing all the high points and corners. This will leave a thin, weak shell, held together with resin (but no fiberglass fibers). ___ ___ ___ ___

8. A complete rebuild is now possible by using fiberglass matting. Pieces saturated with resin should be laid on the back side of the thin shell. This is done by shingling the area (overlapping the pieces). ___ ___ ___ ___

   (NOTE: Do not try to work with pieces that are too large. Air bubbles should be carefully removed as the mating is laid in place).

9. After all the pieces of fiberglass have cured, apply a coating of plastic filler on the outside of the panel. Then, the area may be smoothed and prepared for painting. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for Competency I4 "Reconstruct Fiberglass Panels.")

UNIT V

JOB SHEET #3, LESSON ONE

SECTION FIBERGLASS PANELS

Equipment:

Vehicle with fiberglass damage
Water and detergent
Wax and grease remover
Grinder or sander
Fiberglass repair kit
Safety glasses and face shield
Gloves
Approved respirator

Procedure:

Evaluation:
3 2 1 N

1. Examine the damaged area and decide how much of the panel to replace. Mark this area with a marking pen, leaving the repair area as small as possible. ___ ___ ___ ___

2. Saw out the section which is to be replaced. Saw out a matching section from a new panel. ___ ___ ___ ___

   (CAUTION: *Double check all measurements to avoid extra work and material waste. Use necessary personal protection).*

3. Clean both top and underside by performing Job Sheet #1. ___ ___ ___ ___

4. Sand both the damaged panel and the replacement panel to insure a good bond between the old and new panel section. ___ ___ ___ ___

5. File all edges of mating sections at an angle to form a "V" joint. ___ ___ ___ ___

6. Cut enough strips of fiberglass cloth to build the repair area slightly above the desired contour. Strips should run the entire length of the repair and overlap two to three inches on each section. ___ ___ ___ ___

7. If possible, use C-clamps to align panels, or use metal strips with screws or rivets. ___ ___ ___ ___

   (NOTE: A reinforcement strip cut from an old panel can also be used to hold a new panel in place, providing, of course, that the underside of the panel is accessible).

Procedure: **Evaluation:**

3 2 1 N

8. Lay the strip on the outside of the panels so that it covers the joint. Drill holes through strip and panel. Mix epoxy resin and hardener and brush on underside where strip is to be placed. Countersink holes in panel so screws or rivets will not need to be removed. Place strip on underside and use screws or rivets to secure it over the seam area. This adds strength to the seam. ___ ___ ___ ___

9. Apply the fiberglass cloth and epoxy resin. ___ ___ ___ ___

   (CAUTION: *Carefully read directions on the product labels and mix accordingly. Mix only the amount needed, as any surplus will be wasted).* ___ ___ ___ ___

10. Saturate the fiberglass cloth strips either by brushing or immersion in the solution of epoxy resin and hardener. Place the saturated strips on the seam area, topside, one at a time, until repair is slightly above the desired contour. ___ ___ ___ ___

11. Brush a coat of resin solution over the entire repair area to make certain all fiberglass is saturated and well bonded. If the fiberglass cloth will not stay in place, a piece of plastic film placed over the repair area will hold the cloth. ___ ___ ___ ___

    (CAUTION: *Clean hands and tools after using epoxy material).*

12. Allow repair area to dry. Grind off excess material until panel assumes the correct contour. The panel is now ready for final filling and refinishing. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for Competency I5 "Section fiberglass panels.")

MODULE: PANEL REPAIRS

UNIT V: FIBERGLASS REPAIR

UNIT V TEST

I. Select the best answer from the five choices listed.

_____1. The two basic types of resin used in fiberglass are: (a) glass and polymers, (b) glass and polyester, (c) polyester and urethane, (d) polyester and epoxy, (e) epoxy and urethane.

_____2. In making fiberglass, the resin is fused with: (a) glass, (b) fiberglass mats, (c) epoxy, (d) polyester, (e) none of the above.

_____3. Which of the following is NOT an advantage of fiberglass? (a) needs no reinforcement, (b) will not rust, (c) is very durable, (d) is light in weight, (e) never produces a rattle.

_____4. It is seldom necessary to replace a whole fiberglass panel because: (a) damage tends to be localized, (b) fiberglass panels are very large, (c) even a totally shattered panel can be easily reconstructed, (d) both a and b, (e) none of the above.

_____5. Panel alignment is very important in fiberglass repair because: (a) they cannot be shifted like metal panels, (b) they cannot be jacked into alignment, (c) misalignment will cause them to crack, (d) both a and b, (e) none of the above.

_____6. When fiberglass is worked with a grinder or sander, the fibers tend to break up into: (a) silicon, (b) epoxy, (c) polyester, (d) millions of particles, (e) either b or c.

_____7. If inhaled, fiberglass particles can cause: (a) cancer, (b) respiratory illness, (c) kidney damage, (d) liver damage, (e) all of the above.

_____8. If fiberglass particles settle on bare skin, they can cause: (a) skin irritation, (b) cancer, (c) kidney damage, (d) liver damage, (e) all of the above.

_____9. Which of following must you wear when grinding or sanding fiberglass? (a) face shield, (b) respirator, (c) safety glasses, (d) tightly buttoned cuffs, (e) all the above.

II. Mark a T if the statement is true and an F if the statement is false.

_____10. You should always wear heavy gloves whenever mixing fiberglass resin.

_____11. Resin mixtures should only be used in well-ventilated areas.

_____12. Mixing resin could cause a fire.

_____13. Some fiberglass resin components can cause blindness if they get into your eye.

_____14. Fiberglass is made from glass fibers.

_____15. All tools used to mix fiberglass should be cleaned immediately, and they can be cleaned with soapy water.

(NOTE: This test is the evaluation for Competency I1 "Identify safety procedures when working with fiberglass," and a score of _____ is necessary for the student to receive evaluation of the Job Sheets in this unit. For Competency I1, a score of ___ = 3, ___ = 2, ___ = 1, ___ or below, student should re-take this test.)

ANSWERS TO UNIT V TEST

1. D
2. B
3. A
4. A
5. D
6. D
7. B
8. A
9. E
10. F
11. T
12. T
13. T
14. T
15. F

MODULE: PANEL REPAIRS

UNIT VI: BUMPERS

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify bumper construction and repair and replace bumpers components. This knowledge will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

Lesson 1:

I. Identify bumper construction (Competencies K1-K4, Unit VI test)

II. Identify energy absorber construction (Competencies K1-K4, Unit VI test)

III. Identify repair and replacement procedures (Competencies K1-K4, Unit VI test)

IV. Demonstrate the ability to:

  a. Remove and replace bumpers, steel or aluminum (Competency K1, Job Sheet #1)

  b. Remove and replace soft facia covers (Competency K3, Job Sheet #2)

MODULE: PANEL REPAIRS

UNIT VI: BUMPERS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Notes to the instructor

C. References

D. Lesson plans

  1. Lesson 1: Bumper Assemblies

    a. Information outline

    b. Job sheets

      JS # 1: Replace bumper absorbers and align bumper
      JS # 2: Remove and replace soft fascia covers

NOTES TO THE INSTRUCTOR

A. The information for Competency K4 "Repair soft fascia covers," is in Unit IV "Plastic Repair." The evaluation is Job Sheet #4, Unit IV.

REFERENCES USED IN WRITING THIS UNIT

1. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

2. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL. 1984.

3. General Motors Corporation. *1987 Body Service Manual (Buick, Oldsmobile, Cadillac).* General Motors Corporation. 1986.

4. Mitchell Information Services, Inc. *Body and Mechanical Parts Service & Repair, Domestic Cars, 1981-85.* Mitchell Information Services. San Diego, CA. 1985.

5. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

MODULE: PANEL REPAIRS

UNIT VI: BUMPERS

LESSON ONE: BUMPER ASSEMBLIES

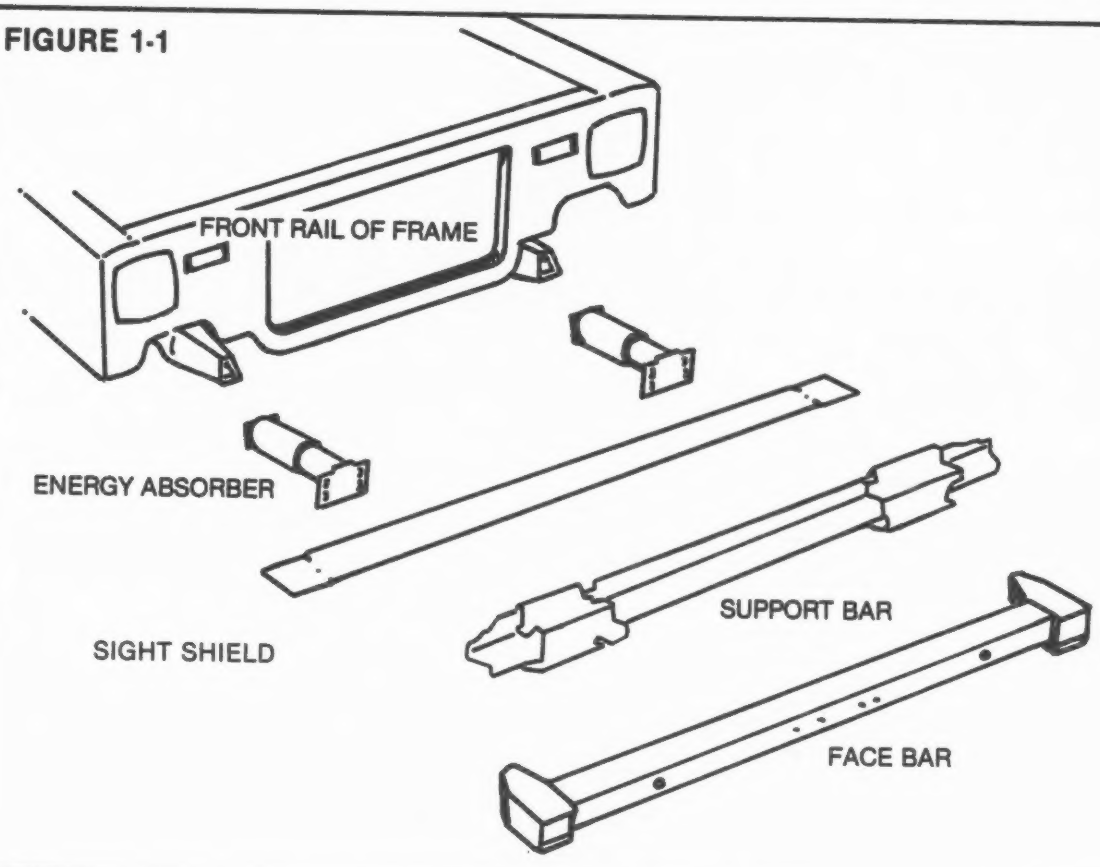
I. **Bumpers**

   A. Functions of bumpers

      1. Protect front and rear panels
      2. Protect sides of fender panels (some designs)
      3. Prevent damage to vehicle from low-speed collisions
      4. Cosmetic appearance of vehicle

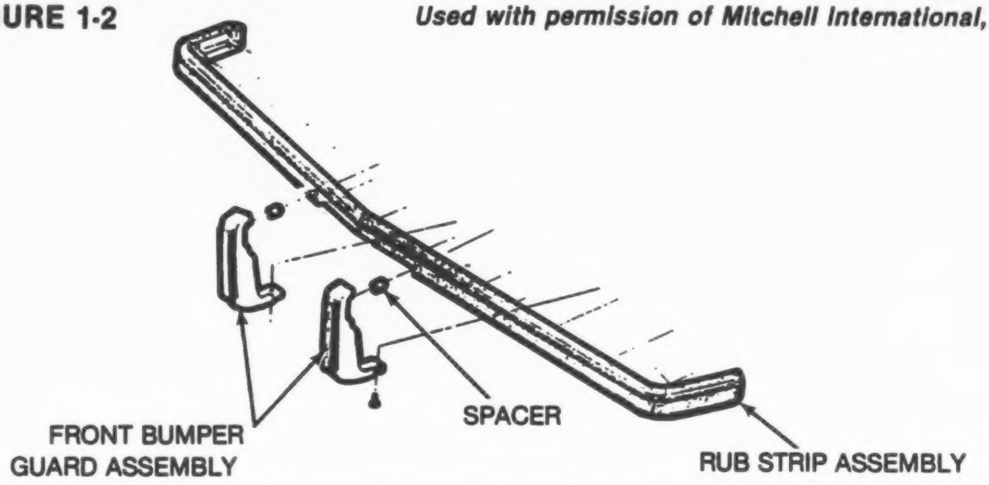
   B. Parts of bumpers (FIG. 1-1)

FIGURE 1-1


FRONT RAIL OF FRAME
ENERGY ABSORBER
SIGHT SHIELD
SUPPORT BAR
FACE BAR

1. Face bar
   a. Exterior portion of bumper assembly
   b. May be variety of designs
   c. Three main coatings: chrome plated, painted, soft (urethane, sometimes called a fascia).
2. Support bar (reinforcement bar)
   a. Located behind and attached to face bar or fascia
   b. Provides strength
3. Bumper guards (FIG. 1-2)

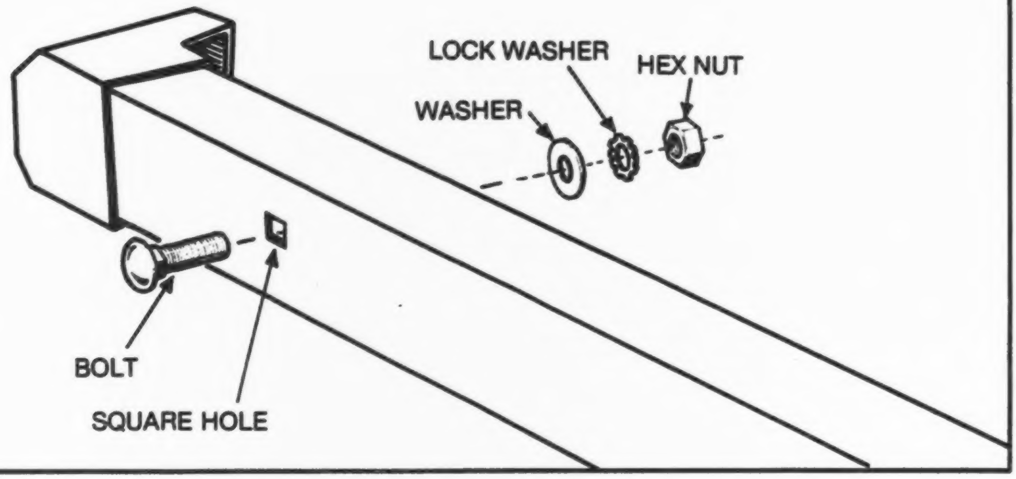
FIGURE 1-2 ***Used with permission of Mitchell International, Inc.***


FRONT BUMPER GUARD ASSEMBLY
SPACER
RUB STRIP ASSEMBLY

   a. Used to prevent another vehicle bumper from riding up over the face bar
   b. Used to accent cosmetic appearance of vehicle

4. Bumper bolts (FIG. 1-3)

FIGURE 1-3



a. Used to fasten face bars to support bars on models with chrome face bars

b. Normally round or oval head with square shank

c. Use a flat washer and lock washer

5. Sight shield

a. Soft rubber material which is painted to match vehicle finish

b. Cosmetic cover for bumper attaching points

c. Flexible and springs back into shape after minor impacts

II. **Impact absorbing bumpers**

A. Most vehicles made since early 1970s have some type of impact absorbing bumpers.

B. Front bumpers are designed to sustain no damage in a 5 mph collision. Rear bumpers designed to sustain no damage in a 2.5 mph collision.

C. Four basic designs

(NOTE: Most later-model vehicles will use either gas-and-fluid-filled or fluid-filled energy absorbers, or impact absorbing pads.)

1. Impact absorbing bolts

a. In collision, bolts and side brackets are deformed, absorbing collision.

b. Vehicle panels and bumper assembly is protected from damage but impact absorbing bolts and end brackets must be replaced.

2. Leaf spring

    a. Bumper is attached to leaf spring-type assembly.

    b. Spring compresses on impact then returns to shape.

    (NOTE: This type is not common on modern vehicles.)

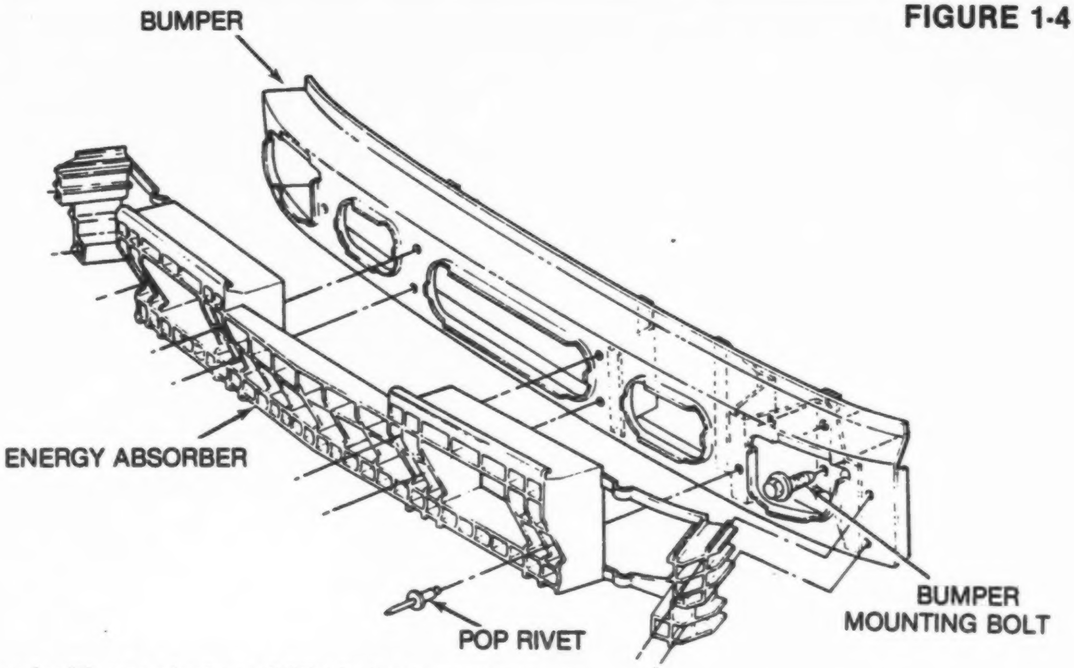
3. Energy absorbing pad (FIG. 1-4)

    a. Located between face far and support bar

    b. Plastic honeycomb pad which compresses on impact and returns to shape

    c. Will have to be replaced if it does not return to shape or is damaged

FIGURE 1-4



Used with permission of Mitchell International, Inc.

4. Gas- or fluid-filled energy absorbers

    a. Attach to vehicle frame or structural panels, with support bar then attached to ends of energy absorbers

    b. Gas- or fluid-filled cylinder compresses in minor collision and returns to shape

    c. May be round or square shaped

   d. Exact construction varies

   e. Those with gas filled components, such as used by General Motors, require special handling procedures. (See below).

III. Repair and replacement of damaged bumper components

A. Chrome face bars

   1. Are sent to a re-chrome shop and exchanged for a re-chromed face bar

   2. Even minor damage to chrome plating cannot be repaired by most body shops

B. Painted face bars

   1. If not badly damaged, may be straightened and/or welded by body shop

   2. Are refinished using normal refinishing procedures

C. Urethane face bars

   1. Unless extensive damage has occurred the urethane fascia can be repaired and refinished, often more economically than it can be replaced.

   2. Repair procedures are outlined in Unit IV - Plastic Repairs of this module.

D. Support bars

   1. If not badly damaged, may be straightened, and/or welded by body shop.

   2. If any spacers are present between support bar and energy absorber or between support bar and face bar, they must be replaced. (The spacers are often used to prevent two different metals from coming in to contact with each other, which can cause corrosion).

E. Bumper guards

   1. Rubber face can be replaced.

   2. If bumper guard is chrome it must be replaced if damaged.

   3. Minor damage to painted guards may be repaired.

F. Bumper bolts

   1. If chrome-plating is damaged they must be replaced.

   2. If threads are damaged they must be rethreaded, if possible, or replaced.

G. Sight shields

   1. May be repaired using techniques outlined in Unit IV, Plastic Repair section of this Module.

2. Must be refinished using appropriate flexible paint additive (See Module 4, "Paint and Refinishing.")

H. Impact-absorbing bolts and side brackets

1. Must be replaced if damaged

2. Damage to other components, such as slider bracket and braces must be checked. Follow service manual recommendations for repair or replacement.

I. Leaf spring

1. Consult service manual recommendations for both repair and replacement.

J. Gas- or fluid-filled energy absorbers

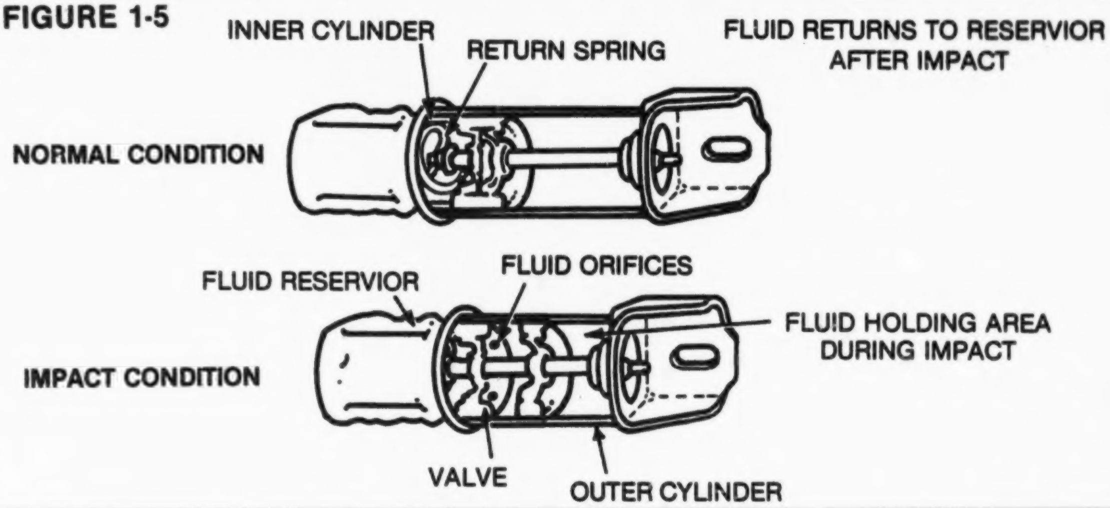
1. Must be checked to see if they are operating properly

2. Must be replaced if damaged (DO NOT REPAIR!)

3. Internal design of fluid-filled absorbers (FIG. 1-5)

a. Two fluid reservoirs with small holes between them allow fluid to slowly move from front reservoir to rear reservoir in a collision.

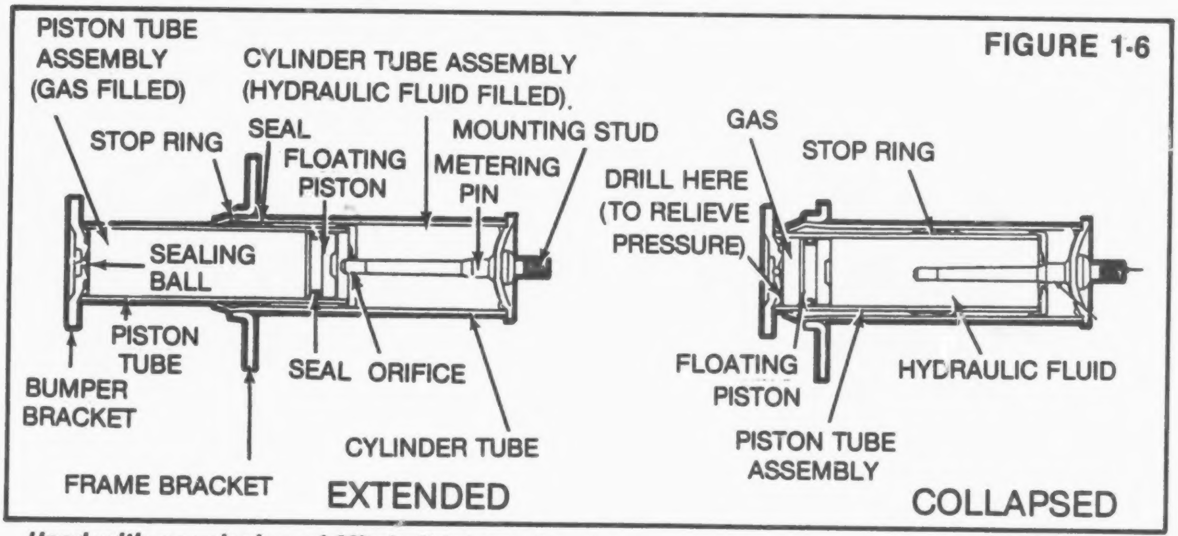
FIGURE 1-5


INNER CYLINDER
RETURN SPRING
FLUID RETURNS TO RESERVIOR AFTER IMPACT
NORMAL CONDITION
FLUID RESERVIOR
FLUID ORIFICES
FLUID HOLDING AREA DURING IMPACT
IMPACT CONDITION
VALVE
OUTER CYLINDER

b. Spring inside of cylinder returns absorber to normal position after collision, unless major damage has occurred.

4. Internal design of gas-and-fluid-filled absorbers (FIG. 1-6)

FIGURE 1-6


PISTON TUBE ASSEMBLY (GAS FILLED)
CYLINDER TUBE ASSEMBLY (HYDRAULIC FLUID FILLED).
STOP RING
SEAL
FLOATING PISTON
METERING PIN
MOUNTING STUD
SEALING BALL
PISTON TUBE
BUMPER BRACKET
SEAL
ORIFICE
CYLINDER TUBE
FRAME BRACKET
EXTENDED
GAS
STOP RING
DRILL HERE (TO RELIEVE PRESSURE)
FLOATING PISTON
HYDRAULIC FLUID
PISTON TUBE ASSEMBLY
COLLAPSED

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K. Mechanical energy absorbers

1. Must be checked for proper operation
2. May be repaired with straightening procedures

L. Checking energy absorbers for damage

1. If absorber is compressed with sufficient force it may be bent and may not spring back.
2. If energy absorber is compressed and does not spring back, it becomes a dangerous part that may spring back at any time, causing potential injury.
3. To replace compressed air- or gas-filled absorbers, use following procedure.
    - a. Wear safety goggles.
    - b. Stand clear of the bumper at all times.
    - c. Attach a chain or cable to the bumper to keep it from flying forward if the pressure is suddenly released.

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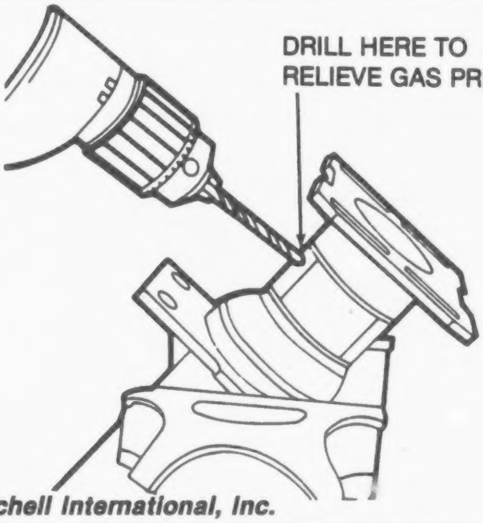
d. Relieve the pressure in the absorber by drilling a small hole in it. This should be done at the front part of the absorber (smaller part). (FIG. 1-7)

FIGURE 1-7



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e. With the pressure relieved, remove and discard the damaged absorber unit.

4. If absorber has returned to normal position, it must be checked for proper working order.

   a. To check, absorber must be compressed at least 3/8 inch and released. It must then return to normal position.

   b. If it does not return to normal position it must be replaced.

5. Use the following procedure to check the absorber.

   a. Move car in front of appropriate barrier.

   b. Turn ignition off, set parking brake, put car in park (automatic) or forward gear (manual).

   c. Place hydraulic or mechanical jack in horizonal position between barrier and energy absorber being tested.

   d. Position jack securely against bumper, using appropriate measures to protect face bar.

   e. Apply pressure with jack, measuring compression until 3/8 inch has been reached.

   f. Release pressure and see if bumper returns to normal position.

g. Repeat procedure for absorber on other side.

(NOTE: If absorbers have been removed from vehicle they can be tested with same procedure except that a shop press is recommended).

M. Safety precautions in working with gas- or fluid-filled energy absorbers

1. Always wear safety goggles when removing or replacing energy absorbers.
2. When removing only one energy absorber, make sure the bumper is properly supported.
3. When checking proper working order of bumpers do not drive car into a barrier under any circumstances.
4. DO NOT apply heat to an energy absorber.
5. DO NOT attempt to weld or bend energy absorbers.

N. Aligning bumpers

1. Consult service manual for specific procedures.
2. Bumper assemblies are often very heavy and two people will often be required to adjust the bumpers.
3. Up-and-down and in-and-out adjustments are often made at the frame or structural panel.
4. Side-to-side face bar adjustments are often made at the slotted holes in the face bar-to-support bar bracket or at the slotted holes in the front of the energy absorber.

UNIT VI

JOB SHEET #1, LESSON ONE

REPLACE BUMPER ABSORBERS AND ALIGN BUMPER

Equipment:

Vehicle service manual
Common hand tools
Safety goggles
Heavy gloves
Hand drill
Chain
Helper

Procedure:

Evaluation:
3 2 1 N

(For most designs remove the bumper face bar and support bar, as a unit, from the energy absorber, then lay bumper face down on a protected area, such as a blanket or piece of carpeting. Consult vehicle service manual before performing this job sheet.)

1. Roll under vehicle, and disconnect any light wires or attachments running to the bumper. ___ ___ ___ ___

2. If energy absorber is compressed, relieve pressure by the following method: ___ ___ ___ ___

    a. Wear safety goggles and stand clear of the bumper at all times.

    b. Attach a chain or cable to the bumper to keep it from flying forward if the pressure is suddenly released.

    c. Relieve the pressure in the absorber by drilling a small hole in it. This should be done at the front part of the absorber.

3. Remove the bumper nuts and bolts. A rust penitrant may be need to help break the bolts loose. ___ ___ ___ ___

4. Have a helper hold the bumper as you remove the last two bolts. ___ ___ ___ ___

Procedure:

Evaluation:
3 2 1 N

5. With the helper, remove the complete bumper assembly from the car and lay it face down on a protected area. ___ ___ ___ ___

6. Remove the bolts attaching the energy absorbers to the body panels and remove the energy absorbers. ___ ___ ___ ___

   (NOTE: If absorbers were not compressed but were of gas-filled type, they must have a hole drilled in them to release pressure before discarding them).

7. If support bar and/or face bar are to be replaced, set the replacement bumper next to the old bumper and transfer all undamaged parts from the old bumper to the replacement. ___ ___ ___ ___

8. Fasten replacement energy absorbers onto vehicle panel, lining up absorbers as near as possible to old location and tighten bolts. ___ ___ ___ ___

9. With a helper, install the replacement bumper on the energy absorbers. Leave the bolts loose to allow for adjustment. ___ ___ ___ ___

10. Adjust bumper by having a helper move the bumper into position, using the adjustment slots. When proper alignment is reached, tighten the bolts. If bumper is too high or too low, absorbers will have to be loosened from body panels and raised or lowered. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the student's final average for Competencies K2 "Replace bumper absorbers" and K1 "Remove and replace bumpers, steel or aluminum.")

UNIT VI

JOB SHEET #2, LESSON ONE

REMOVE AND REPLACE SOFT FACIA COVERS

Equipment:

Common hand tools, as required
Helper, if required
Safety goggles

(NOTE: Due to the wide variety of attaching methods, vehicle service manual will have to be consulted for exact procedure and equipment. The steps of procedure following are for evaluation purposes only and are not exact steps required).

Procedure:

Evaluation:
3 2 1 N

1. Remove bumper guards, if required. ___ ___ ___ ___

2. Remove clips and/or bolts attaching soft fascia to bumper reinforcement. ___ ___ ___ ___

   (NOTE: On some procedures, the fascia and reinforcement are removed as a unit and the fascia is then removed from the reinforcement).

3. Replace fascia according to service manual and re-attach to vehicle. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the student's final average for Competency K3 "Remove and replace soft fascia covers).

MODULE: PANEL REPAIRS

UNIT VI: BUMPERS

UNIT VI TEST

I. Select the best answer from the five choices listed.

_____1. The outside, cosmetic, portion of the bumper is called the: (a) fascia, (b) face bar, (c) support bar, (d) either a or b, (e) none of the above.

_____2. The inside, reinforcing, portion of the bumper is called the: (a) fascia, (b) face bar, (c) support bar, (d) either a or b, (e) none of the above.

_____3. Bumper guards may prevent damage to the bumper by preventing: (a) damage to the support bar, (b) another bumper from riding up over the face bar, (c) damage to the energy absorber, (d) damage to the fascia, (e) all of the above.

_____4. The sight shield is used to: (a) cover bumper attaching points, (b) protect the fascia, (c) protect the support bar, (d) protect the energy absorber, (e) none of the above.

_____5. Which of the following is NOT a type of energy-absorbing bumper component: (a) impact absorbing bolts, (b) leaf spring, (c) energy absorbing pad, (d) compression face bar, (e) gas-filled energy absorbers.

_____6. Gas- or fluid-filled energy absorbers must be checked for proper operation by: (a) striking with a hammer, (b) compressing 3/8 of an inch, (c) drilling a hole in the side, (d) extending 1/2 inch, (e) none of the above.

_____7. The proper method of repairing a gas- or fluid-filled energy absorber is to: (a) replace the gas or fluid, (b) straighten bent parts, (c) drill a hole to release excess pressure, (d) a and b, (e) none of the above.

_____8. A compressed energy absorber which does not spring back is dangerous because: (a) it may spring back without warning, (b) it may be leaking toxic gas, (c) it may be bent such that the gas will explode, (d) it may be so compressed it generates heat, (e) all of the above.

II. Mark a T if the question is true and an F if the question is false.

_____9. You should apply heat to an energy absorber only with an approved heat gun.

_____10. You should attempt to weld energy absorbers only with a MIG welder.

_____11. You should always wear safety goggles when removing or replacing energy absorbers.

_____12. Driving a car into a barrier to check the energy absorbers is an acceptable practice if safety rules are followed.

_____13. Due to their weight, special jacks should be used when working with bumpers.

_____14. Bumpers can only be adjusted from side to side, never inward or outward.

_____15. The three main coatings for a face bar are: chrome, paint, and urethane.

(NOTE: Completion of this test with a minimum score of _____ is necessary for the student to receive evaluations on Competencies K1-K4.)

ANSWERS TO UNIT VI TEST

1. D
2. C
3. B
4. A
5. D
6. B
7. E
8. A

9. F
10. F
11. T
12. F
13. F
14. F
15. T

MODULE: PANEL REPAIRS

UNIT VII: CORROSION PROTECTION

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify corrosion protection procedures and apply corrosion protection. This knowledge will be evidenced through demonstration, and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

Lesson 1:

I. Match terms with their definitions (Competency G8, Unit VII test)

II. Identify corrosion and its effects (Competency G8, Unit VII test)

III. Identify corrosion protection procedures (Competency G8, Unit VII test)

IV. Demonstrate the ability to:

   a. Apply corrosion protection (Competency G8, Job Sheet #1)

MODULE: PANEL REPAIRS

UNIT VII: CORROSION PROTECTION

CONTENTS OF THIS UNIT

A. Objective sheet

B. Notes to the instructor

C. References

D. Lesson plans

1. Lesson 1: Corrosion protection

   a. Information outline

   b. Job sheets

      JS # 1: Apply corrosion protection

   c. Unit test

   d. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Due to the importance of corrosion protection and due to the many application situations encountered it is recommended that the student receive an evaluation for this job sheet every time corrosion protection is applied and that all of the resulting evaluations be averaged to arrive at a final evaluation.)

REFERENCES TO BE USED IN WRITING THIS UNIT

1. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

2. General Motors Corporation. *1987 Body Service Manual (Buick, Oldsmobile, Cadillac).* General Motors Corporation. 1986.

3. Inter-Industry Conference on Auto Collision Repair. Unibody Auto Collision Repair Training Program. *Restoring Corrosion Protection.* Inter-Industry Conference on Auto Collision Repair. Des Plains, IL. 1986.

4. Mitchell Information Services, Inc. *Body and Mechanical Parts Service & Repair, Domestic Cars, 1981-85.* Mitchell Information Services. San Diego, CA. 1985.

5. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

6. Scharff, Robert. *Motor Auto Body Repair.* Delmar Publishers, Inc. Albany, NY. 1988.

MODULE: PANEL REPAIRS

UNIT VII: CORROSION PROTECTION

LESSON ONE: CORROSION PROTECTION

I. **Terms and definitions**

A. Adhesion -- The ability of one substance to stick to another, unlike substance.

B. Conversion coating -- Liquid, zinc-rich material applied to bare metal following the application of wax and grease remover and metal conditioner. It provides adhesion for primer coats and prevents rust.

C. Corrosion -- The electrochemical process of oxygen combining with a metal and destroying the strength of the metal. Commonly called rust.

D. Cosmetic panels -- Any vehicle panels which do not contribute to the structural strength of a vehicle, such as hoods, trunk lids and door skins.

E. E-Coat -- Short for cathodic electrodeposition, which is a factory method of applying epoxy-type primer to vehicle panels to prevent corrosion. In this process the vehicle is dipped into a bath of positive-charged paint, while the vehicle itself is negatively charged.

F. Epoxy primer -- Special primer recommended for bare metal applications which provides excellent corrosion protection.

G. Hot spot -- A small area of unprotected metal which corrodes at a high rate because corrosion is concentrated in the spot due to the surrounding area being protected.

H. Metal conditioner -- A liquid containing an acid which is applied to bare metal to remove microscopic rust.

I. Spray wand -- A pressure-feed device for spraying corrosion protection into the inside of closed sections.

J. Structural panels -- Any panels which contribute to the structural strength of a vehicle.

K. Wax and grease remover -- Special cleaner designed to remove wax, grease and other contaminants from a surface prior to applying corrosion protection.

L. Weld-through primer -- Special primer material applied to weld joints prior to welding in order to provide corrosion protection for the weld zone.

M. Zinc coating (Galvanizing) -- A coating of the metal zinc over steel to increase corrosion protection.

II. **Corrosion and its effects**

A. Corrosion

1. Corrosion is a chemical reaction which happens to metal when it is exposed to oxygen and/or water.

2. In the process of corrosion oxygen and hydrogen (from water) combine with the iron in steel to produce iron oxide (rust). The same process happens to other metals, producing aluminum oxide, zinc oxide, etc., but steel is especially vulnerable to corrosion.

3. Corrosion results in the breakdown of the metal.

4. If unchecked, the metal will be completely eaten away.

5. Unprotected metal corrodes at a uniform rate, but if only a small area of the metal is subject to corrosion, the small, unprotected area will rust rapidly due to complex chemical processes. This rapid rusting of a small unprotected area is called a "Hot spot."

B. The increased need for corrosion protection

1. The need for corrosion protection has increased due to the dominance of the unibody vehicle.

2. In the unibody vehicle many panels combine to provide the structural integrity of the vehicle.

3. If structural panels corrode they will weaken the vehicle.

4. Automakers are providing excellent corrosion protection at the factory and any collision repair must restore corrosion protection because:

   a. Any rust-proof warranty must be maintained by the repair.

   b. Weakened panels due to improper corrosion protection could result in the repairman being liable for damages, including failure of the strength of the vehicle in an accident.

5. Proper corrosion protection, properly applied, is critical for the interior surfaces of closed sections (rocker panels, rails and pillars) because they are critical to the structural integrity of the unibody vehicle.

6. Three things must be present for corrosion to take place - metal, oxygen and an electrolyte (water). To prevent corrosion either water or oxygen or both must be prevented from reaching the metal.

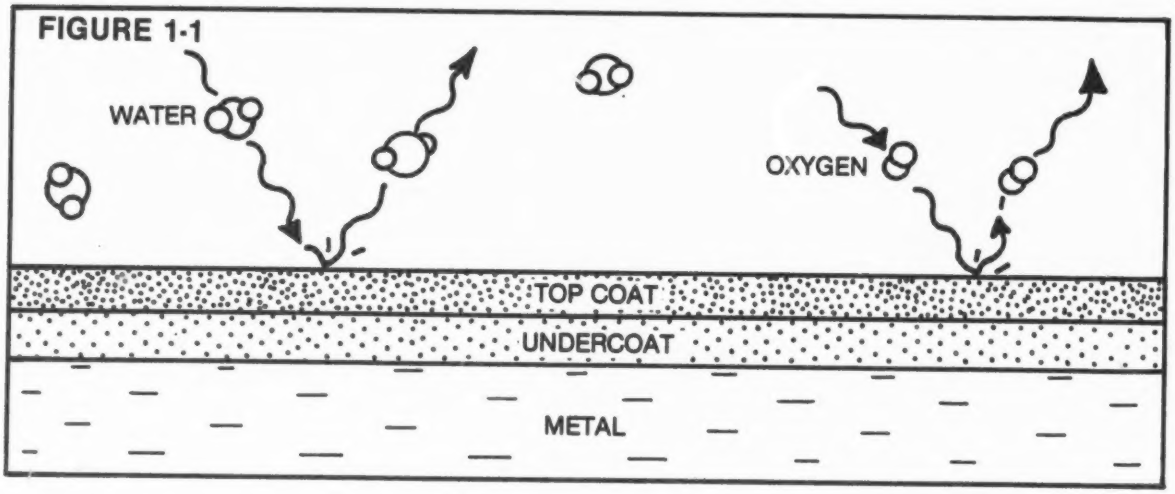
III. Methods of preventing corrosion

A. Corrosion is prevented by keeping oxygen and/or water from reaching the metal.

B. There are two methods of corrosion protection (both used in most corrosion protection procedures).

1. Sealing the metal by the use of undercoating and topcoating materials (primers, sealers and colorcoats). (FIG. 1-1)

FIGURE 1-1

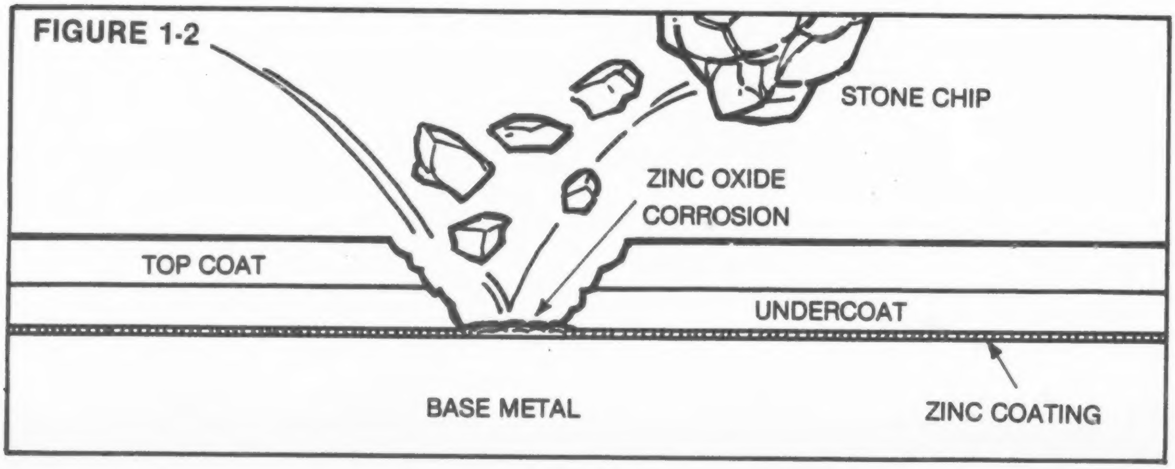

WATER
OXYGEN
TOP COAT
UNDERCOAT
METAL

   a. Properly sealing the metal prevents air and water from reaching the surface as long as the coating material is in good condition

   b. Metal panels must be sealed on both sides

2. Coating the metal with zinc (FIG. 1-2)

FIGURE 1-2


STONE CHIP
ZINC OXIDE
CORROSION
TOP COAT
UNDERCOAT
BASE METAL
ZINC COATING

   a. Zinc helps reduce corrosion because the outer coating of zinc will corrode first.

   b. When it corrodes, zinc forms zinc oxide, which itself forms a barrier against corrosion for the metal underneath.

C. Process of corrosion protection applied by vehicle manufacturers

1. Vehicle assembly is first submerged in chemical cleaner, then rinsed.

2. Vehicle is then submerged in a conversion coating and then neutralized in a water.

3. Vehicle is then submerged in E-coat epoxy primer.

4. Primer-surfacer then color coat is sprayed on.

D. Corrosion protection methods of vehicle manufacturers cannot be duplicated in repair procedures, but equal protection can be achieved.

E. Types of materials used by auto body repairman to prevent corrosion

1. Wax and grease remover -- Must be applied as a first step in preparing a surface for corrosion protection.

2. Metal conditioner -- Applied to bare metal in appropriate cases to remove microscopic rust.

   (NOTE: Metal conditioner must be neutralized by thorough rinsing with water before other materials are applied. The rinsing must be done with a clean silicone-free rag to completely remove the metal conditioner).

3. Conversion coating -- Applied after metal conditioner to promote adhesion and inhibit corrosion.

   (NOTE: Conversion coatings must be neutralized by thorough rinsing with water before other materials are applied. The rising must be done with a clean, silicone-free rag).

4. Weld-through primer -- Applied to joints prior to welding in order to provide corrosion protection for the weld areas, which cannot be reached after the weld is completed.

5. Epoxy primer -- Epoxy-based primer which is recommended by many vehicle manufacturers for maximum corrosion protection.

6. Primer-surfacer and primer-sealer -- Primer materials applied over epoxy primer (See Module 4 on Paint and Refinishing).

7. Seam sealers -- Thick material applied to seams on vehicle joints to seal the seams from air and moisture. There are four types of sealers:

   a. Thin-bodied sealers -- Used on seams with narrow gaps of 1/8 inch or less.

   b. Heavy-bodied sealers -- Used on seams with gaps of 1/8 inch to 1/4 inch.

   c. Brushable sealers -- Used on interior seams where appearance will not be noted.

   d. Solid sealers -- Used to fill large seams.

8. Undercoating – Thick material sprayed onto underside of vehicle to inhibit corrosion and deaden noise in passenger compartment.

F. Guidelines for applying weld-through primers

1. Apply only over bare steel only.

2. Apply a thin coating only.

3. Galvanized sheet metal does not require the use of a weld-through primer.

4. Apply only in the immediate area.

5. After welding, thoroughly remove all residue.

6. Clean weld area with a plastic abrasive or sandblaster. (A wire brush can leave deep scratches which can lead to trapped moist air underneath a primer).

7. After welding a closed section it is necessary to use an airless system to apply primer inside the surface. Use the system recommended by the primer manufacturer.

8. Follow primer manufacturer's recommendations on safety.

G. There are different application procedures for corrosion protection depending on whether the area receiving the protection is an exposed or enclosed surface, whether it is an interior or exterior surface, or whether joints and seams are involved. It is recommended that I-CAR procedures be followed.

H. Additional considerations in corrosion protection

1. Protective coatings may be damaged in areas of indirect damage as well as the primary impact area. Always check for seams pulled apart, loose caulking, or paint chips in areas beyond the primary impact area.

2. Follow all safety procedures recommended by the manufacturer of the corrosion protection material being applied. The use of rubber gloves, eye protection, protective clothing and a respirator is recommended for many applications. Follow the directions on the label.

3. Paint products are usually manufactured as paint systems. In applying corrosion protection it is necessary to first determine the type of topcoat (if any) to be applied and follow the topcoat manufacturer's recommendations for all undercoating and corrosion protection materials. DO NOT mix products from one manufacturer's paint system with another manufacturer's paint system unless the label specifically states they are compatible.

4. Cleaning must begin with removal of visible rust and defective paint.

5. Treat closed sections first, otherwise solvents and chemicals from treatments on other areas may run into the untreated closed sections, where they cannot be properly removed.

6. DO NOT use lacquer-based primers over bare metal, even if properly prepared with metal conditioner and conversion coating, on unibody vehicles. They will not provide adequate adhesion.

7. When using OEM replacement parts you must apply a primer to the replacement parts. The primer covering the OEM part does not provide adequate adhesion.

8. Be sure to restore any spacer protection between dissimilar metals, such as aluminum against steel. An example is to be sure and replace the spacer between aluminum bumpers and steel energy absorbers. Follow vehicle manufacturer's recommendations in re-attaching all trim components. (Spacers are often in the form of heavy, transparent, plastic tape.)

   (NOTE: Having dissimilar metals next to each other will result in a process known as galvanic corrosion, which will quickly destroy any corrosion protection present and then accelerate the corrosion of the metal).

9. When applying undercoatings, be sure you do not get overspray on moving parts, such as glass-run channels, window regulators, drive axles, etc., or to energy absorbing bumper components or shock absorbers.

10. After applying undercoatings, be sure that all body drain holes are left open.

UNIT VII

JOB SHEET #1, LESSON ONE

APPLY CORROSION PROTECTION

Equipment:

Steel panel with bare metal area
Sandpaper
Water
Clean rag (free from silicone-type coating)
Metal conditioner
Conversion coating
Primer (Epoxy-type recommended)
Primer-surfacer or primer-sealer
Sealer, if required
Topcoat
Undercoating

(NOTE: This job sheet is not an exact steps of procedure, but it covers all possible procedures for corrosion protection. Follow the steps of procedure outlined in this unit for type of application you are performing. The state of Missouri recommends that I-CAR procedures be followed.)

Procedure:	**Evaluation:** 3	2	1	N
1. After metal is properly cleaned of old paint and/or visible rust, apply metal conditioner, if necessary, and properly rinse.				
2. Apply conversion coating, if necessary, and properly rinse.				
3. Apply primer.				
4. Apply seam-sealer, if necessary, and re-apply primer.				
5. Apply primer-surfacer, if needed.				
6. Apply primer-sealer, if needed.				
7. Apply undercoating, if needed.				
8. Apply topcoat, if needed, following procedures and job sheets in Module 4: Paint and Refinishing.				
Average of above evaluations*				

(*This average is the evaluation for Competency G8 "Apply corrosion protection.")

UNIT VII TEST

CORROSION PROTECTION

I. Match the term in the right column with the most closely associated word or phrase in the left column.

_____1. A small area of unprotected metal which corrodes at a high rate

_____2. Liquid containing an acid which is applied to bare metal to remove microscopic rust

_____3. Pressure-feed device for spraying corrosion protection inside of closed sections

_____4. Special cleaner used first in corrosion protection procedures

_____5. Factory method of applying epoxy-type primer to vehicle panels

_____6. Special primer recommended for bare metal applications

_____7. The ability of one substance to stick to another, unlike substance

_____8. Liquid, zinc-rich material applied to bare metal

_____9. Electrochemical process of oxygen combining with a metal

_____10. Special primer applied to weld joints

_____11. A metal coating to provide increased corrosion protection

A. Zinc

B. Spray wand

C. E-coat

D. Corrosion

E. Hot spot

AB. Epoxy

AC. Metal conditioner

AD. Conversion coating

AE. Coat sprayer

BC. Wax and grease remover

BD. Weld-through primer

BE. Adhesion

CD. Undercoat

II. Select the best answer from the choices listed.

_____12. The three things necessary for corrosion are: (a) water, salt, electrolyte, (b) water, oxygen, salt, (c) water, oxygen, metal, (d) oxygen, salt, metal, (e) any of the above.

_____13. Corrosion protection has become more important in recent years because: (a) cars have gotten more expensive, (b) new paints do not work, (c) the unibody dominates, (d) you can no longer use lacquer, (e) government regulations are stricter.

_____14. Two important reasons to restore the corrosion protection properly in a vehicle repair are: (a) warranties and liabilities, (b) warranties and customer relations, (c) liabilities and customer relations, (d) customer relations and federal regulations, (e) liabilities and federal regulations.

_____15. Although it is very important to provide good corrosion protection everywhere, one place on unibodies which is critical is the: (a) pillars, (b) underbody, (c) interior of passenger compartment, (d) interior of closed sections, (e) door intrusion barrier.

_____16. A type of metal which helps reduce corrosion in steel when applied as a coating over steel is: (a) copper, (b) zinc, (c) high strength steel, (d) lead, (e) aluminum.

_____17. The type of seam sealer used on gaps of 1/8 inch to 1/4 inch is: (a) e-coat, (b) thin-bodied, (c) thick-bodied, (d) brushable, (e) solid.

_____18. The type of seam sealer used on wide gaps is: (a) e-coat, (b) thin-bodied, (c) thick-bodied, (d) brushable, (e) solid.

_____19. The type of seam sealer used on narrow gaps of 1/8th inch or less is: (a) e-coat, (b) thin-bodied, (c) thick-bodied, (d) brushable, (e) solid.

_____20. The type of sealer used on interior, unexposed, seams is: (a) e-coat, (b) thin-bodied, (c) thick-bodied, (d) brushable, (e) solid.

_____21. A special rust-proofing and sound-deadening material for vehicle underbodies is: (a) undercoating, (b) zinc oxide, (c) conversion coating, (d) sealer, (e) dum dum.

_____22. In making major repairs, the places to treat first are: (a) the worst places, (b) the underbody, (c) the structural panel exteriors, (d) the closed section interiors, (e) the cosmetic surfaces.

_____23. A paint material you cannot use over bare metal, even if the metal is properly prepared is: (a) conversion coating, (b) e-coat, (c) metal conditioner, (d) lacquer-based primer, (e) wax and grease remover.

_____24. When using OEM replacement parts you must apply: (a) a primer, (b) a metal conditioner, (c) a conversion coating, (d) a spray wand, (e) an e-coat.

_____25. You must retain any spacers between dissimilar metals because having two different metals together produces: (a) iron oxide, (b) galvanic corrosion, (c) panel shifting, (d) hot spots, (e) zinc oxide.

(NOTE: Completion of this unit test with a minimum score of _____ is necessary for the student to receive an evaluation on Job Sheet #1, this unit, "Apply corrosion protection.")

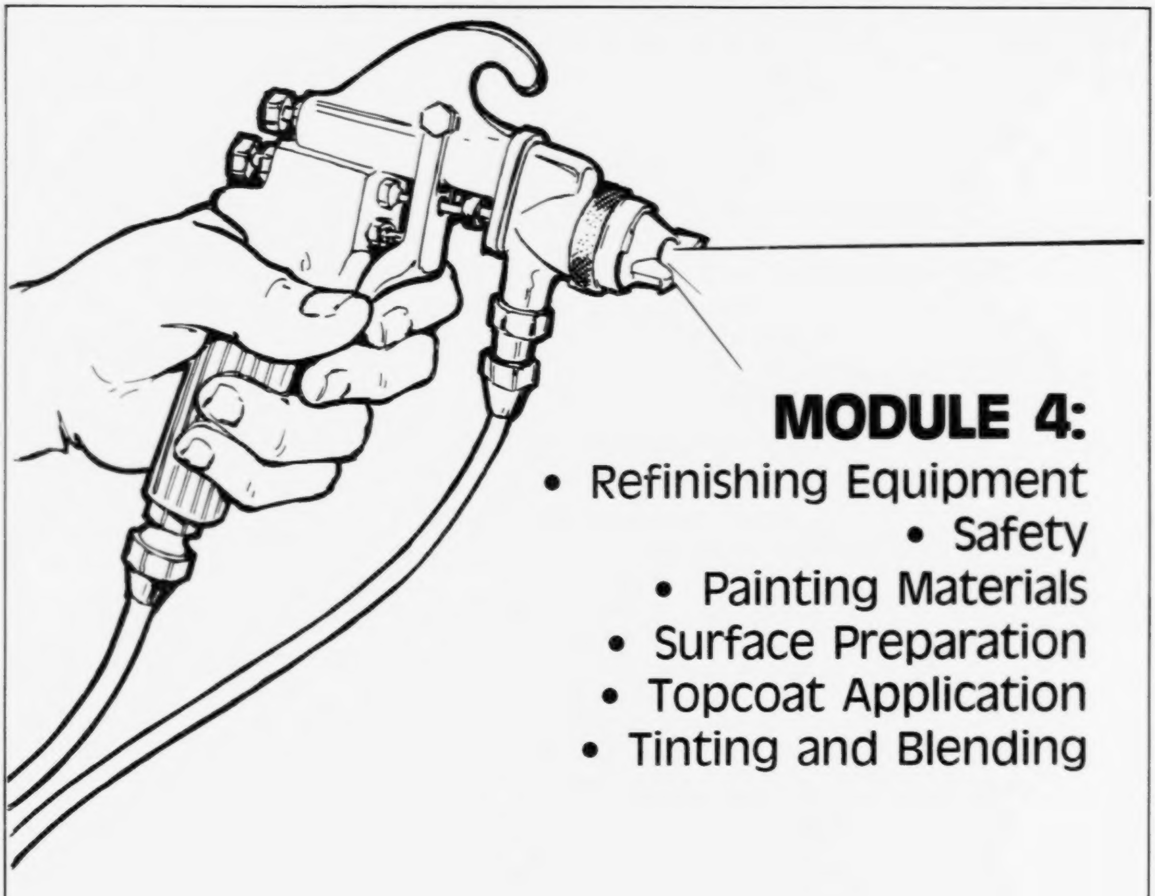
ANSWERS TO UNIT VI TEST

1. E
2. AC
3. B
4. BC
5. C
6. AB
7. BE
8. AD
9. D
10. BD
11. A

12. c
13. c
14. a
15. d
16. b
17. c
18. e
19. b
20. d
21. a
22. d
23. d
24. a
25. b

Auto Body Repair Curriculum Guide

INSTRUCTOR'S GUIDE



MODULE 4:

- Refinishing Equipment
- Safety
- Painting Materials
- Surface Preparation
- Topcoat Application
- Tinting and Blending

Paint and Refinishing

INSTRUCTIONAL MATERIALS LABORATORY • UNIVERSITY OF MISSOURI • COLUMBIA, MISSOURI 65211 • 314/882-2883

AUTO BODY CURRICULUM
Instructor's guide

MODULE 4:
PAINT AND REFINISHING

Written by Roger Helms

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314/882-2884
July 1988

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Auto Body

Paint and Refinishing

Cross-Reference Table of Instructional Materials

Competency	Unit	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
L 1	I	1-I, 1-II	1-3				1-18	
L 2	I	2-I					19-38	
L 3	II	1-I--1-III	1-4			1	1-37	
L 4	II	1-IV-b				2		
L 5	II	1-IV-c				3		
M 1	III	1-I--1-III	1				1-50	
		2-I--2-III					1-50	
M 2	III	1-I--1-III				1	1-50	
M 3	III	1-I--1-III				2-4	1-50	Also JS3, U II, Lesson 2
M 4	III	1-I--1-III	1			5	1-50	
M 5	III	1-I--1-III	1			6, 7	1-50	
M 6	III	1-I--1-III	1			8	1-50	
M 7	III	2-I--2-III				1	1-50	
M 8	III	2-I--2-III				1	1-50	
M 9	IV	1-I--1-III, 2-I--2-V					1-45	
M 10	IV	1-I--1-III, 2-I--2-V				1	1-45	
M 11	IV	1-I--1-III, 2-I--2-V				3	1-45	
M 12	IV	1-I--1-III, 2-I--2-V				4	1-45	
M 13	IV	1-I--1-III, 2-I--2-V, 3-I				5	1-45	Also JS1, Lesson 3
M 14	V	1-I--1-IV				1	1-20	
M 15	V	2-I--2-II				1	21-30	
M 16	V	2-I--2-II				2	21-30	

MODULE: PAINT AND REFINISHING

UNIT I: EQUIPMENT AND SAFETY

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify refinishing equipment and identify safety equipment and safety rules for refinishing operations. Mastery will be evidenced by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1: I. Identify refinishing equipment (Competency L1, Part I of Unit I test)

II. Identify the parts of the suction-feed spray gun (Competency L1, Part I of Unit I test)

Lesson 2: I. Identify safety hazards and safety equipment (Competency L2, Part II of Unit I test)

MODULE: PAINT AND REFINISHING

UNIT I: EQUIPMENT AND SAFETY

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

    1. Lesson 1: Refinishing Equipment

        a. Information outline

        b. Transparency masters

            TM#1: Working principle of siphon-feed spray gun
            TM#2: Parts of siphon-feed spray gun
            TM#3: Lubrication of siphon-feed spray gun

    2. Lesson 2: Safety and Safety Equipment

        a. Information outline

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Students should pass the safety test with an appropriately high score before performing job sheets in this module.

REFERENCES USED IN WRITING THIS UNIT

1. Binks Manufacturing Company. *Air Spray Manual.* Binks Manufacturing Company. Franklin Park, IL. 1985.

2. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

3. Czapskie, George S., et. al. *Auto Body Repair.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1977.

4. The DeVilbiss Company. *The ABC's of Spray Equipment for Refinishing.* The DeVilbiss Company. Toledo, OH. 1981.

5. du Pont, E.I. *Auto Refinishing Handbook.* E.I. du Pont de Nemours & Co. Wilmington, DE. 1985.

6. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL. 1984.

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9. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

10. Toboldt, Bill. *Auto Body Repairing and Repainting.* The Goodheart-Willcox Co. Inc. South Holland, IL. 1982.

11. Walker, Susan, and VanWinkle, James. *Automotive Body Refinisher.* Curriculum & Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education. Stillwater, OK. 1986.

MODULE: PAINT AND REFINISHING

UNIT I: EQUIPMENT AND SAFETY

LESSON ONE: REFINISHING EQUIPMENT

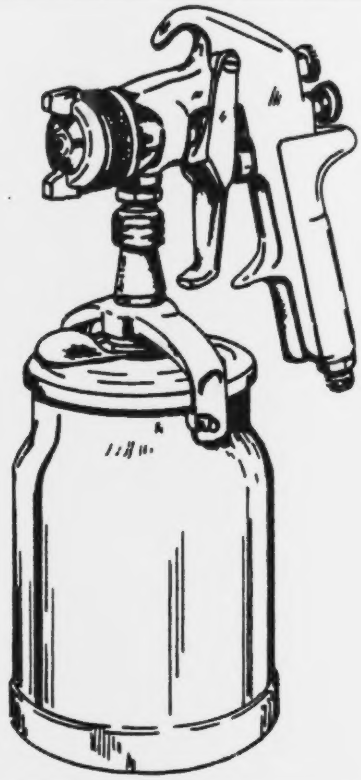
I. **Refinishing equipment**

   A. Paint spraying equipment

      1. Siphon-feed spray gun -- Paint spray gun in which compressed air, flowing through an opening around the fluid tip in the spray gun, creates a vacuum. Vacuum allows atmospheric pressure to push paint up and out of the siphon cup (FIG. 1-1).

         (NOTE: The siphon-feed spray gun will be used in most auto body applications.)

FIGURE 1-1

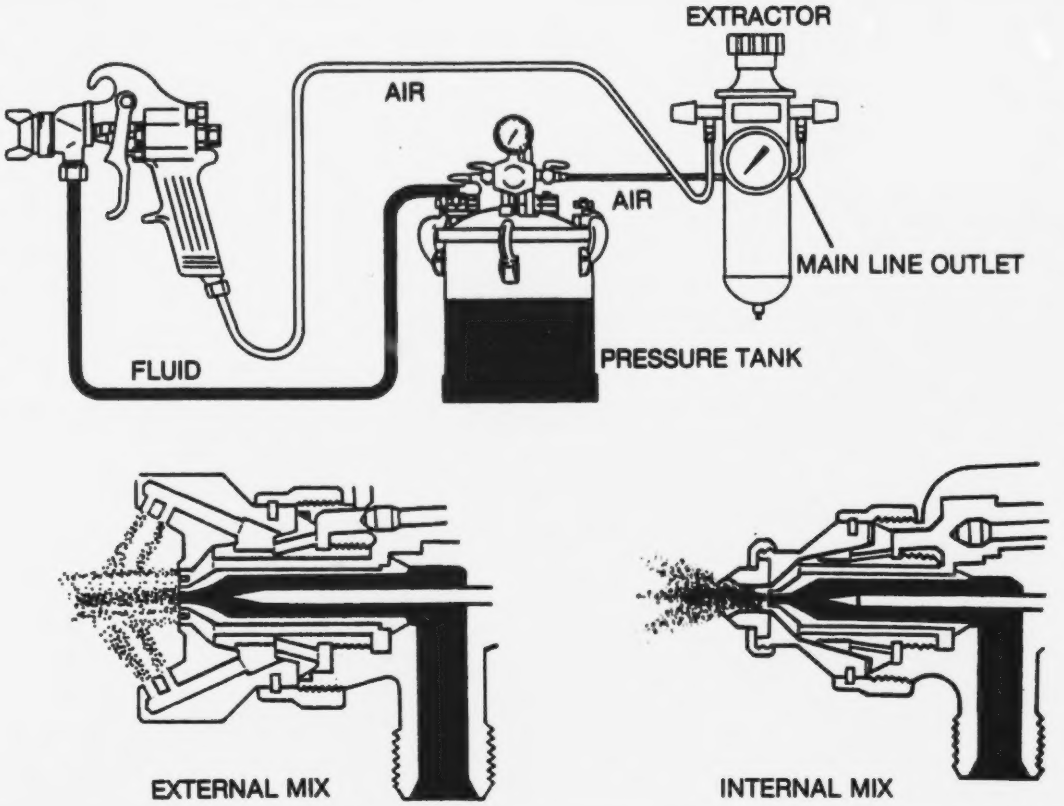


2. Pressure-feed spray gun -- Paint spray gun in which compressed air forces paint from a pressurized tank, through a hose to the gun. Used on large jobs or in assembly-line situations (FIG. 1-2).

   (NOTE: Pressure-feed spray guns may be either external-mix guns or internal-mix guns. In external-mix guns, the paint is mixed with air outside the gun. In internal-mix guns, the paint is mixed with air inside the gun. External-mix guns are used in most refinishing operations.)

FIGURE 1-2

Courtesy of Binks Manufacturing Company



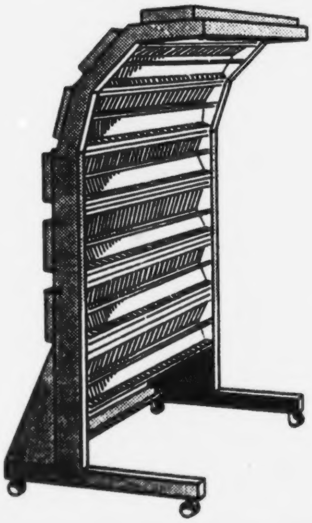
3. Regulator/separator -- Special pressure regulator used in spray operations. It is located on the air compressor and serves the dual purpose of regulating air pressure and separating oil and water from the air.

4. Air compressor -- A device with an electric motor driving a compressor, which uses a storage tank and regulator to provide compressed air for auto body repainting operations.

5. Paint booth -- A large room, totally enclosed and sealed, designed to provide a dust-free environment for vehicle refinishing. Most are designed with air-infiltration systems which eliminate many overspray problems, and heat systems that dry the paint.

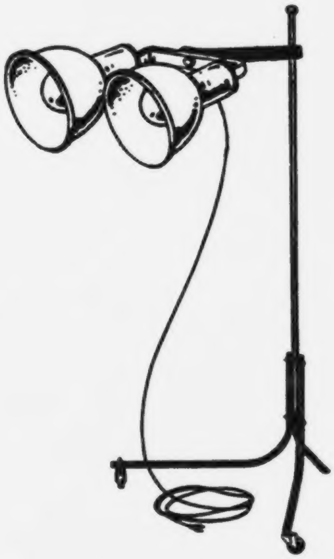
6. Panel drying system -- A paint drying system used to dry a large area by means of forced dry air and/or heat over vehicle panel(s). (FIG. 1-3)

FIGURE 1-3



7. Spot repair drying system -- A paint drying system used to dry a small area by means of forced dry air and/or heat over a spot repair (FIG. 1-4).

FIGURE 1-4



B. Paint mixing equipment

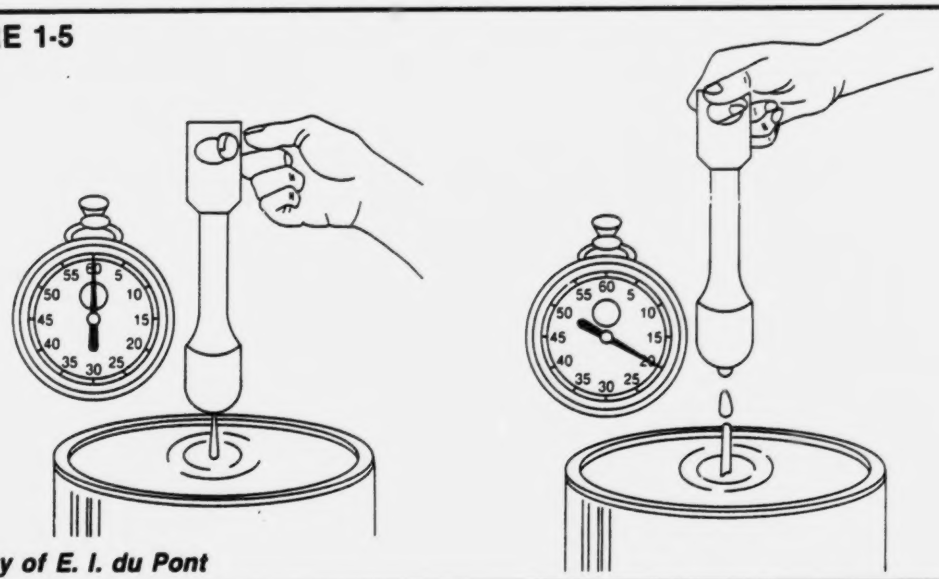
1. Paint paddle -- A metal, wood, or plastic stick used to stir and mix paint thoroughly.

2. Paint mixer -- Mixing machine that shakes cans of paints vigorously to mix particles. Electric mixers are now being replaced by pneumatic mixers for safety reasons.

3. Paint strainer -- A funnel-shaped device used to strain out any dirt, scum or other impurities in paint as it is poured into spray gun.

4. Viscosity cup -- A measuring device that allows the painter to measure the thickness (viscosity) of paint by determining how long it takes it to drip through the viscosity cup (FIG. 1-5).

FIGURE 1-5



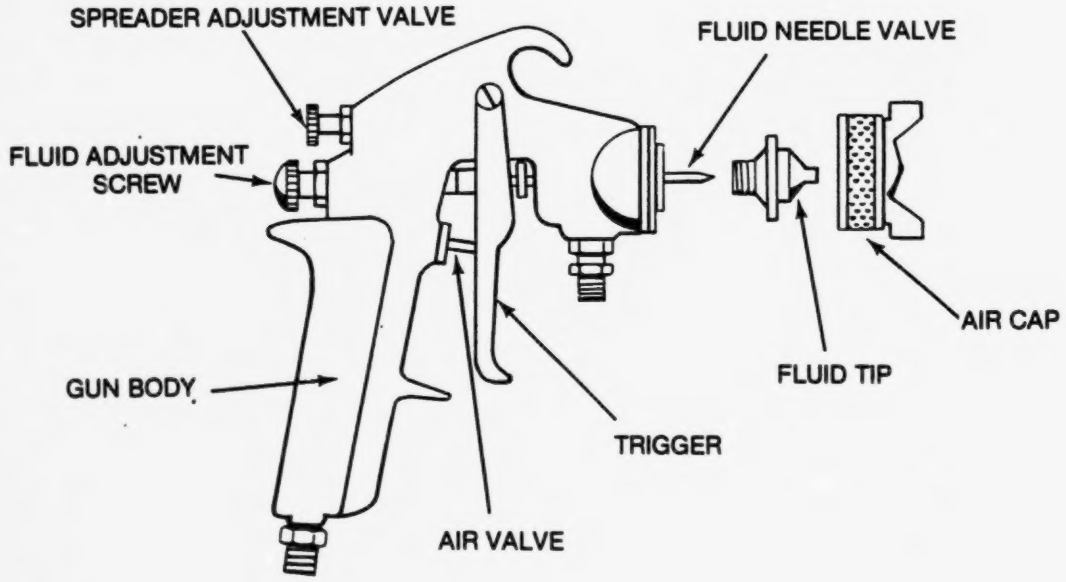
Courtesy of E. I. du Pont

II. The suction-feed spray gun (FIG. 1-6)

A. Parts of the suction-feed spray gun

1. Spray adjustment valve
2. Fluid adjustment screw
3. Fluid needle valve
4. Air valve
5. Trigger
6. Fluid tip
7. Air cap

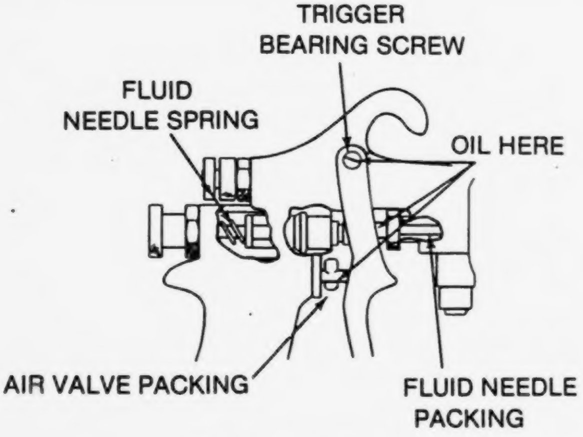
FIGURE 1-6


SPREADER ADJUSTMENT VALVE
FLUID NEEDLE VALVE
FLUID ADJUSTMENT SCREW
AIR CAP
FLUID TIP
GUN BODY
TRIGGER
AIR VALVE

B. Lubrication of the suction-feed spray gun.

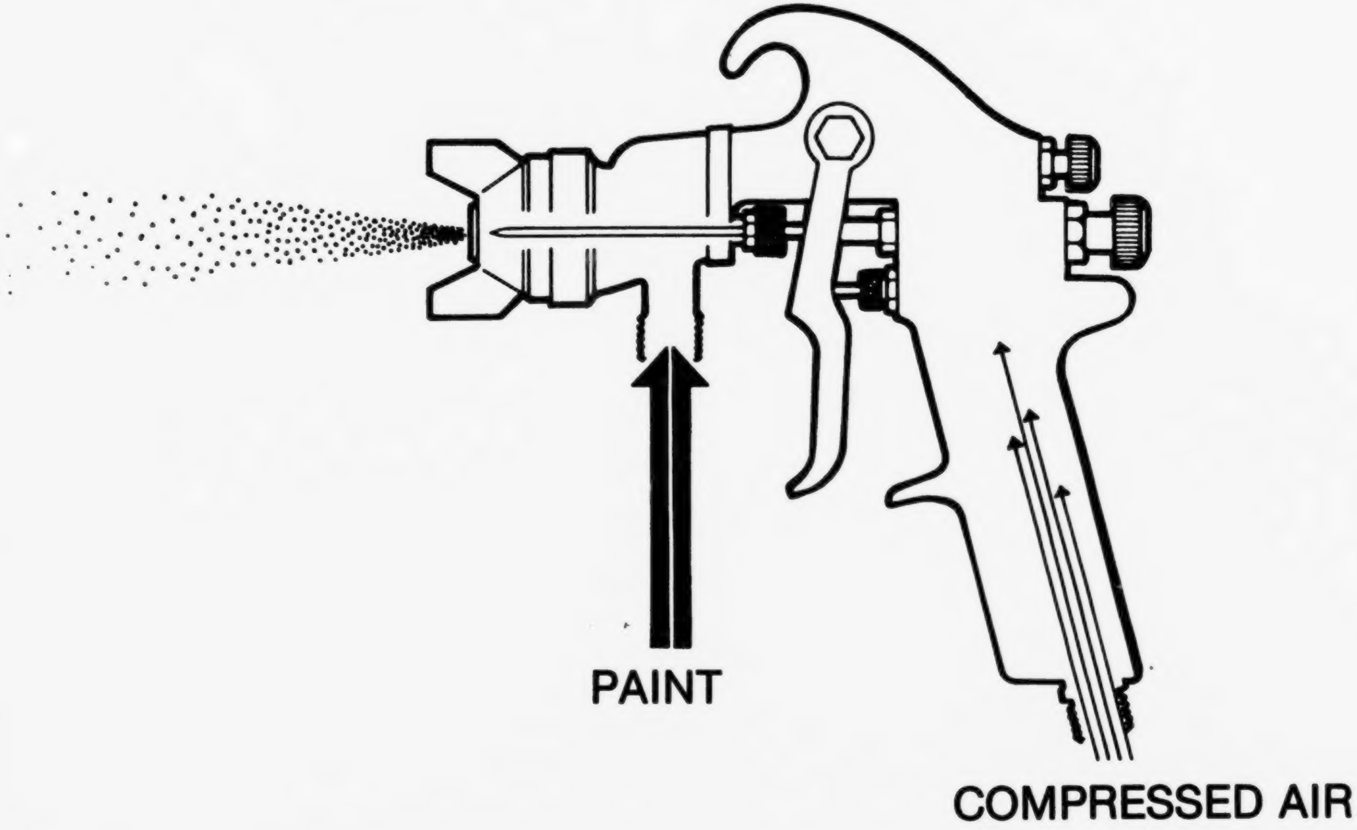
FIG. 1-7

FIGURE 1-7


TRIGGER BEARING SCREW
FLUID NEEDLE SPRING
OIL HERE
AIR VALVE PACKING
FLUID NEEDLE PACKING

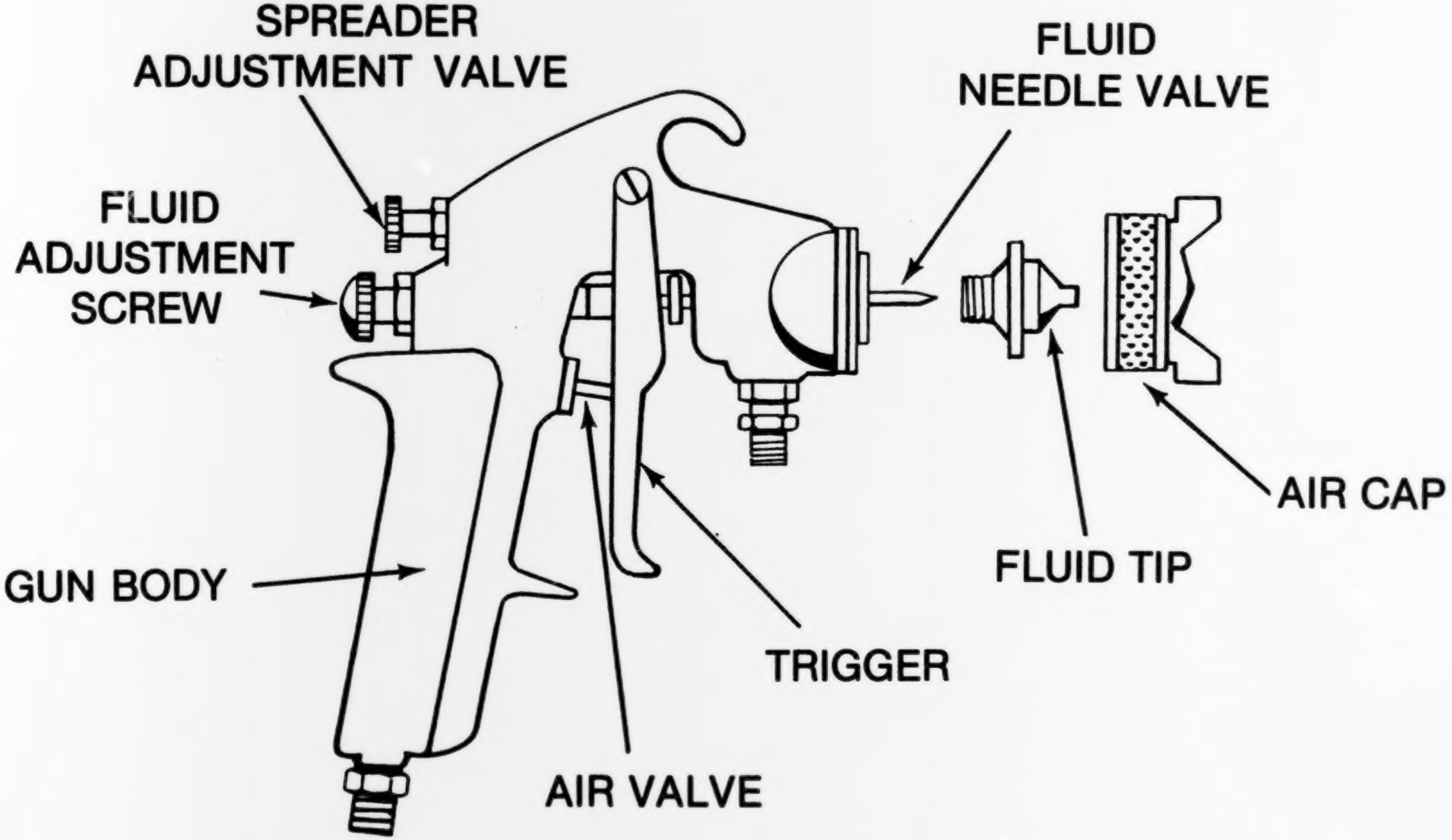
POINTS OF LUBRICATION

How the Suction Feed Paint Gun Works

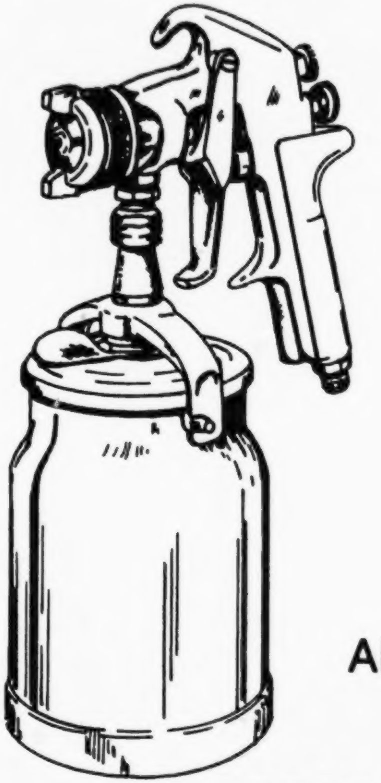

PAINT
COMPRESSED AIR

Adapted with permission of Binks Manufacturing Company

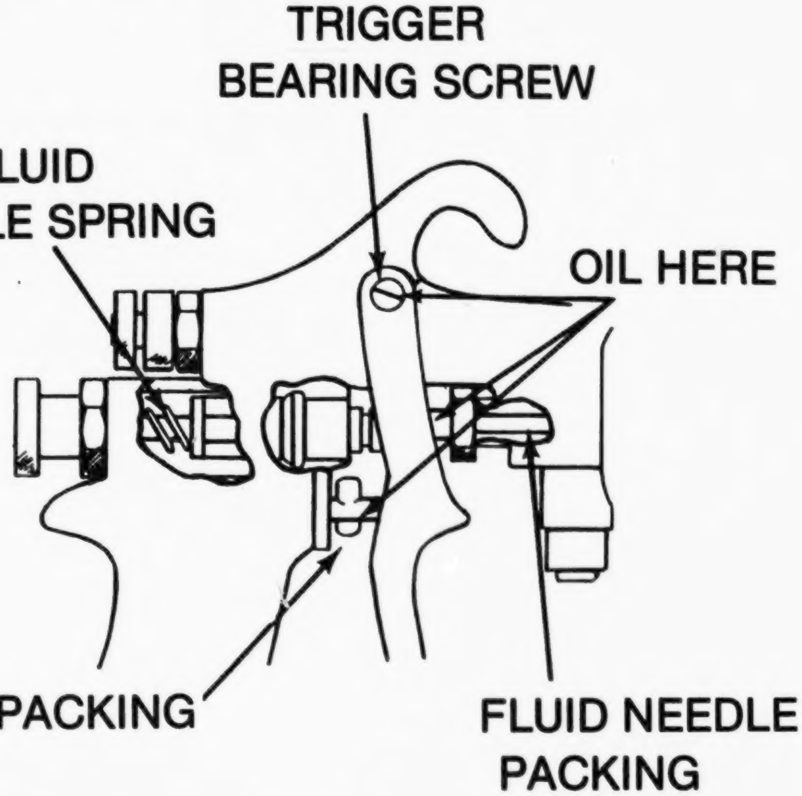
Principle Parts of the Spray Gun


SPREADER ADJUSTMENT VALVE
FLUID NEEDLE VALVE
FLUID ADJUSTMENT SCREW
AIR CAP
FLUID TIP
GUN BODY
TRIGGER
AIR VALVE

Spray Gun and Points of Lubrication



SPRAY GUN


TRIGGER
BEARING SCREW
FLUID
NEEDLE SPRING
OIL HERE
AIR VALVE PACKING
FLUID NEEDLE
PACKING

POINTS OF LUBRICATION

MODULE: PAINT AND REFINISHING

UNIT I: EQUIPMENT AND SAFETY

LESSON TWO: SAFETY AND SAFETY EQUIPMENT

I. **Safety hazards and safety equipment in refinishing**

A. Safety hazards

1. Paint fumes can cause headaches and stomachaches. Some paint fumes are poisonous.

2. Paint particles (atomized droplets of paint in the air) can cause breathing problems because they will stick to the lung's air passages and partially clog the breathing system.

3. Paints and paint products can damage the eyes

    a. All paint products are capable of causing some eye trouble.

    b. Some paint products are capable of causing blindness if splashed into the eyes.

4. The dust from sanding can get into and damage the lungs.

5. Skin on hands can become irritated from constant exposure to painting materials.

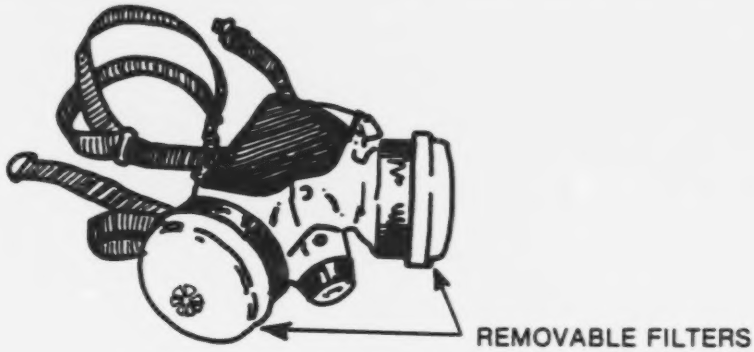
6. Skin on hands can be injured in sanding and grinding operations.

7. For the above reasons, breathing equipment, eye protection and gloves are ABSOLUTELY necessary for many refinishing procedures.

B. Breathing safety equipment for refinishing

1. Respirator with removable filters (FIG. 2-1)

FIGURE 2-1



a. Filters out paint particles and most paint fumes by filtering air being breathed

b. Filters must be replaced -- never cleaned

c. Replace filters after each complete paint job

d. Some type of respirator is absolutely necessary for safe paint work and a respirator with removable filters is recommended for most activities.

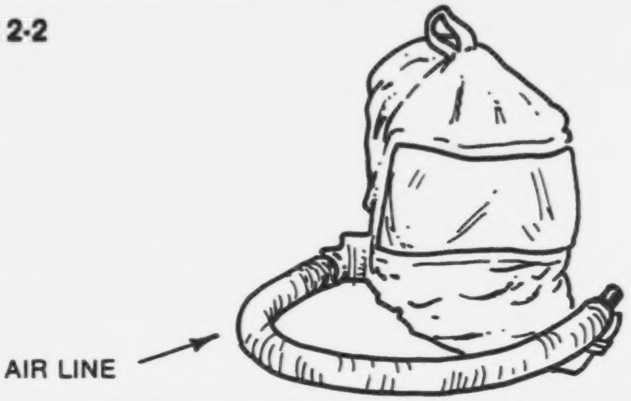
2. Air-supply respirator (FIG. 2-2)

a. Provides air to be breathed through air line from an air compressor

b. Hose assembly belted to waist to avoid damaging hose

c. Recommended when working with toxic paints, such as paints with isocyanates.

FIGURE 2-2



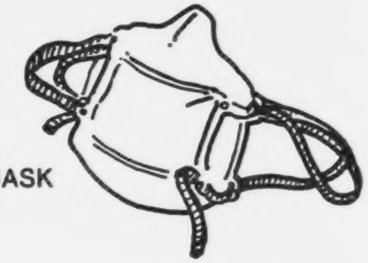
3. Particle mask (FIG. 2-3)

a. Disposable mask used for sanding operations

b. Keeps particles of refinishing material and metal dust from getting into worker's lungs.

c. Should be used in all sanding operations

FIGURE 2-3



PARTICLE MASK

C. Eye and hand safety equipment for refinishing

1. Safety goggles

   a. Protect eyes from particles and paint overspray by almost completely sealing off eyes.

      (**CAUTION:** *Safety goggles are NOT the same thing as safety glasses.)*

   b. Must be worn whenever working with paint materials that could harm the eye, including mixing and spraying refinishing equipment.

2. Face shield

   a. Protects face and eyes from particles and sparks in sanding and grinding operations

   b. Should be worn, along with a particle mask, in all sanding and grinding operations.

3. Gloves

   a. Rubber gloves should be worn whenever working with paints, thinners, plastic filler and many other refinishing materials -- follow recommendations on material being used.

   b. Heavy leather gloves with gauntlets should be worn in sanding and grinding operations.

4. Clothing

   a. Heavy clothing that covers all exposed skin should be worn whenever working with paint and refinishing materials.

      (**CAUTION:** *Some material is difficult to wash off of skin and some material may harm skin on contact.)*

   b. Disposable coveralls are recommended, if available.

D. General safety rules for paint equipment

1. Always wear recommended protective clothing.
2. Do not allow any unprotected person in the work area of sanding, grinding or spraying operations.
3. Always obey instruction and caution labels on all refinishing materials.
    a. Protect against inhaling or swallowing fumes.
    b. Protect against contact with eyes or skin.
4. NEVER use compressed air to dry the skin or to remove dust from skin or clothes.

   (NOTE: Compressed air is released with enough pressure to put out an eye.)
5. Never place a bare hand over the outlet nozzles of spray equipment when spraying.
6. Never make repairs or service equipment unless all electric or pneumatic power has been properly disconnected.
7. Do not overload circuits by connecting extra electrical equipment to a circuit in or near a paint room or paint material storage area. Most paint materials are flammable and some are explosive.

MODULE: PAINT AND REFINISHING

UNIT I: EQUIPMENT AND SAFETY

UNIT I TEST

PART I–REFINISHING EQUIPMENT

I. Match the following definitions with the correct terms

_____1. Pressure-feed spray gun

_____2. Siphon-feed spray gun

_____3. Regulator-separator

_____4. Air compressor

_____5. Paint booth

_____6. Panel drying system

_____7. Spot repair drying system

_____8. Paint paddle

_____9. Paint mixer

_____10. Paint strainer

_____11. Viscosity cup

A. Enclosed room for painting

B. Uses remote paint reservoir

C. Uses paint cup

D. Stirs paint mechanically

E. Stirs paint manually

AB. Removes impurities

AC. Measures paint thickness

AD. Cures large area of paint

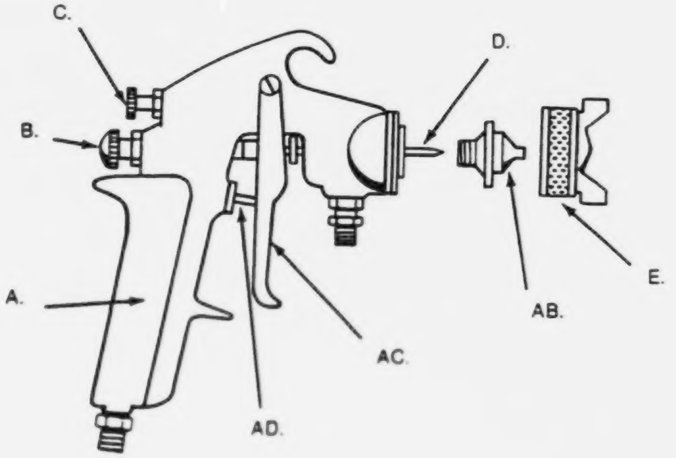
AE. Cures small area of paint

BC. Provides air pressure

BD. Removes water, controls pressure

II. Match the letter on the suction-feel spray gun below with the correct term for the part in the list below.

_____12. Spreader adjustment valve
_____13. Fluid adjustment valve
_____14. Fluid needle valve
_____15. Air valve
_____16. Trigger
_____17. Fluid tip
_____18. Air cap



(NOTE: Completion of part one of this unit test is the evaluation for Competency L1 "Identify refinishing equipment" of the 18 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this portion of the test.)

PART II—PAINTING SAFETY

I. Mark a T on the test or answer sheet if the statement is true and an F if the statement is false.

_____19. Paint fumes can cause headaches and stomachaches and some paint fumes are poisonous.

_____20. Paint particles can cause breathing problems because they will stick to the lung's air passages and partially clog the breathing system.

_____21. Some paint products are capable of causing blindness if splashed into the eyes.

_____22. Dust from sanding can be inhaled, damaging the lungs.

_____23. Bare hands need not be protected in refinishing operations.

_____24. The removable filters in a respirators should be cleaned often.

_____25. An air-supply respirator is recommended when working with paints containing isocyanates.

_____26. A charcoal mask should be worn while sanding.

_____27. A particle mask should be used in spot painting operations.

_____28. Safety glasses should be worn whenever working with paint materials that could harm the eyes.

_____29. A face shield should be worn in all sanding and grinding operations.

_____30. Rubber gloves should be worn whenever working with paints, thinners and many other refinishing materials.

_____31. Heavy leather gloves with gauntlets should be worn in sanding and grinding operations.

_____32. Heavy clothing that covers all exposed skin would be too hot to wear in most painting operations.

_____33. Disposable coveralls are not heavy enough for protection during paint spraying operations.

_____34. It is not necessary to read and follow the instruction and caution labels on all refinishing materials if one has used similar materials in the past.

_____35. Using compressed air to clean skin and clothing is a good idea.

_____36. They only way to get a good feel for how a spray outlet nozzle is working is to put a bare hand over it.

_____37. When making repairs on equipment, all pneumatic or electric power to the equipment should be disconnected.

_____38. An overloaded circuit in the paint booth could cause a spark, which could cause an explosion.

(NOTE: Completion of part two is the evaluation for competency L2 "Use safe painting practices, including the use of protective clothing and equipment." Of the 20 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this portion of the test.)

ANSWERS TO UNIT I TEST

PART I.

1. B
2. C
3. BD
4. BC
5. A
6. AD
7. AE
8. E
9. D
10. AB
11. AC

12. C
13. B
14. D
15. AD
16. AC
17. AB
18. E

PART II.

19. T
20. T
21. T
22. T
23. F
24. F
25. T
26. F
27. F
28. F
29. T
30. T
31. T
32. F
33. F
34. F
35. F
36. F
37. T
38. T

MODULE: PAINT AND REFINISHING

UNIT II: SPRAYING TECHNIQUES AND EQUIPMENT MAINTENANCE

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify proper spraying techniques and proper equipment maintenance. Mastery will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Identify spray gun control procedures (Competency L3, Unit II test)

II. Identify proper spraying techniques (Competency L3, Unit II test)

III. Identify trouble-shooting procedures (Competency L3, Unit II test)

IV. Demonstrate the ability to:

  a. Use the paint gun with proper technique (Competency L3, Job Sheet #1)

  b. Service and maintain a spray gun (Competency L4, Job Sheet #2)

  c. Service and maintain the paint room (Competency L5, Job Sheet #3)

MODULE: PAINT AND REFINISHING

UNIT II: SPRAYING TECHNIQUES AND EQUIPMENT MAINTENANCE

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

  1. Lesson 1: Spraying Equipment and Techniques

    a. Information outline

    b. Transparency masters

      TM#1: Proper spraying techniques
      TM#2: Proper spraying techniques
      TM#3: Proper spraying techniques
      TM#4: Proper spraying techniques

    c. Job sheets

      JS#1: Use the paint gun with proper technique
      JS#2: Service and maintain a spray gun
      JS#3: Service and maintain the paint room

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. On Job Sheet #1 the instructor must be sure that all factors except gun technique have been eliminated as possible causes of poor application results.

REFERENCES USED IN WRITING THIS UNIT

1. Binks Manufacturing Company. *Air Spray Manual.* Binks Manufacturing Company. Franklin Park, IL. 1985.

2. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

3. Czapskie, George S., et. al. *Auto Body Repair.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1977.

4. The DeVilbiss Company. *The ABC's of Spray Equipment for Refinishing.* The DeVilbiss Company. Toledo, OH. 1981.

5. du Pont, E.I. *Auto Refinishing Handbook*. E.I. du Pont de Nemours & Co. Wilmington, DE. 1985.

6. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair*. Second edition. Bennett Publishing Company. Peoria, IL 1984.

7. The Martin-Senour Company. *A Guide to Better Automotive Refinishing*. Martin-Senour Company. Countryside, IL 1984.

8. Miller Electric Mfg. Co. *Fundamentals of Gas Metal-Arc (MIG) Welding*. Appleton, WI. N.D.

9. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair*. Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

10. Toboldt, Bill. *Auto Body Repairing and Repainting*. The Goodheart-Willcox Co. Inc. South Holland, IL 1982.

11. Walker, Susan, and VanWinkle, James. *Automotive Body Refinisher*. Curriculum & Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education. Stillwater, OK. 1986.

MODULE: PAINT AND REFINISHING

UNIT II: SPRAYING TECHNIQUES AND EQUIPMENT MAINTENANCE

LESSON ONE: SPRAYING TECHNIQUES AND EQUIPMENT MAINTENANCE

I. **Spray gun control procedures**

  A. The three main spraying situations

    1. Spot repair - Painting a portion of one panel

      a. Requires less air pressure than other repairs for acrylic lacquer and acrylic enamel

      b. Requires blending (see Unit V, Lesson 1)

    2. Panel repair - Painting an entire panel or panels

      a. Done when damage is extensive to panel, or spot repairs are needed on two or more areas of panel

    3. Complete refinishing - Painting an entire vehicle

      a. May be done when many panels must be painted

      b. May be done due to bad condition of old paint or due to owner's request for a color change

  B. Factors which spray gun operator must control

    1. Air pressure

    2. Gun adjustments

    3. Gun movement

  C. Air pressure

    1. Should be measured at gun

    2. If pressure is measured at compressor, gun pressure is reduced as length of hose increases and diameter of hose decreases. Various charts are available to determine how to compensate for this.

    3. Air pressure must be set according to manufacturer's recommendations for type of paint and type of application.

4. General guidelines for air pressure

Paint	Spot repair psi	Panel/complete psi
Primer surfacer	40-45	40-45
Acrylic lacquer	20-35	40-45
Acrylic enamel	30-40	50-65
Alkyd enamel	50-60	50-60
Polyurethane enamel (non-metallic)	50	50
Polyurethane enamel (metallic)	65	65
Flexible finish	35	35

D. Spray gun adjustments

1. Set pressure at gun

2. Set fan adjustment screw (air flow)

   a. Wide open for complete panels--turn screw counterclockwise until it stops

   b. Less than wide open for spot repairs

3. Set fluid adjustment screw

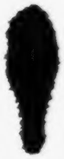
   a. Wide open for most applications--turn screw counterclockwise until one thread appears (further turning will not affect fluid adjustment).

   b. If less than wide open is desired, adjust by turning counterclockwise from open position and testing spray until desired adjustment is reached.

E. Spray pattern problems

1. Top heavy (FIG 1-1)

FIGURE 1-1



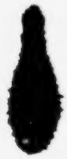
a. Horn holes partially clogged

b. Obstruction on top of fluid tip

c. Dirt on air cap seat or fluid tip seat

2. Bottom heavy (FIG. 1-2)

FIGURE 1-2

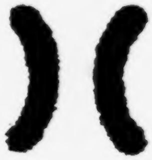


a. Horn holes partially clogged

b. Obstruction on bottom of fluid tip

3. Heavy on right side or left side (FIG. 1-3)

FIGURE 1-3



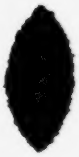
a. Right or left side horn hole partially clogged

b. Dirt on right or left side of fluid tip

c. Right or left jet clogged

4. Heavy center (FIG. 1-4)

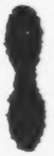
FIGURE 1-4



  - a. Too low of setting on the fan adjustment
  - b. Paint too thick
  - c. Too much air pressure
  - d. Nozzle too large or too small for material being sprayed

5. Split spray (FIG. 1-5)

FIGURE 1-5



  - a. Fan adjustment too high
  - b. Too low of fluid flow

II. Spray application techniques

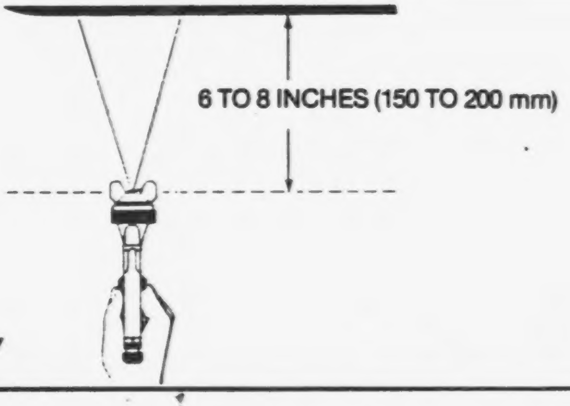
A. Hold gun proper distance from panel (FIG. 1-6)

  1. 6 to 8 inches for lacquer
  2. 8 to 10 inches for enamel

B. Check shape of spray pattern

  1. Hold 8 inches (200 mm.) from test panel, with gun level and perpendicular to panel. Pull trigger all the way back and then release.

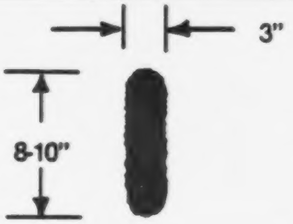
FIGURE 1-6



Courtesy of
Binks Manufacturing Company

2. Spray pattern should be 8 to 10 inches high and 2 to 3 inches wide (FIG. 1-7)

FIGURE 1-7



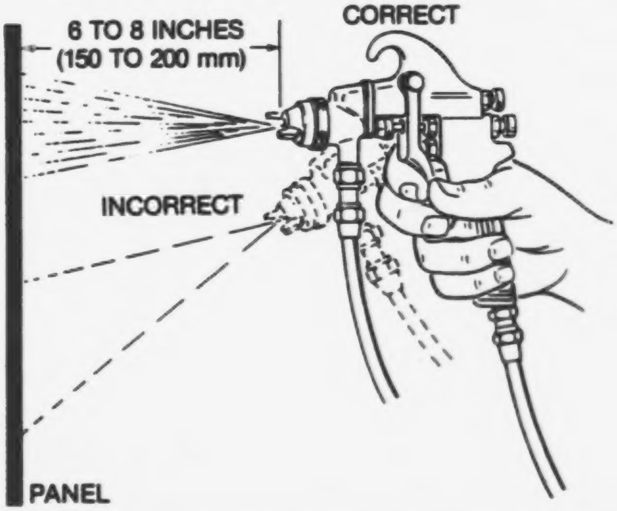
C. Check texture of spray pattern

1. If coating is rough, dry or without luster, either:
    a. Decrease air pressure by 5 psi
    b. Open fluid adjustment wider
2. If coating is too wet, with sags, ripples or orange peel, increase air pressure at gun by 5 psi.
3. Make adjustments until proper texture is reached.

D. Hold gun level and at right angles to panel

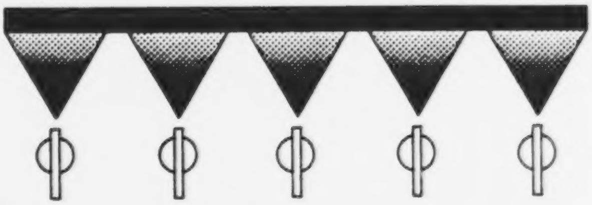
1. Keep wrist still
2. Move gun in steady, sweeping strokes
3. Practice holding gun level, moving steadily, and keeping gun perpendicular to surface. The two most common problems of apprentices are arcing the gun and tilting the gun. (FIG. 1-8, 1-9)

FIGURE 1-8



Courtesy of Binks Manufacturing Company

FIGURE 1-9



Courtesy of E. I. du Pont

E. Applying paint

1. Starting a panel

   a. Aim gun nozzle at top of panel and several inches to one side

   (NOTE: The idea is to get the center part of the spray pattern to cover the starting point on panel. Half of spray should be off of panel)

   b. Pull trigger and start moving gun sideways across panel

   c. Move at steady, even rate

   d. Move approximately one foot per second

   e. Move at uniform speed without stopping, keeping gun vertical and level

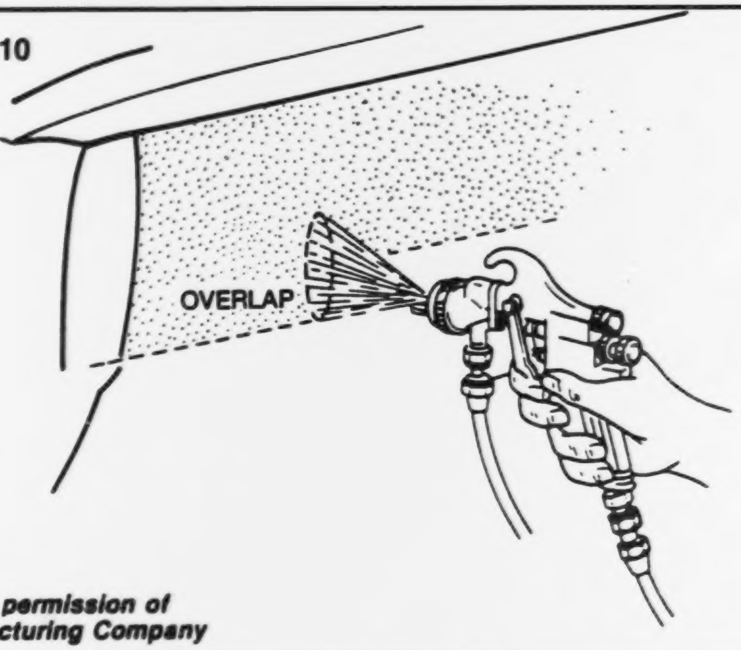
   f. 18 to 36 inches should be maximum length of strokes

   g. Release trigger at end of pass enough to stop fluid flow without stopping air flow

   h. Drop down one-half the height of spray pattern, pull trigger and start pass back in opposite direction. (FIG. 1-10)

   (NOTE: Each pass should start such that the center of the spray pattern is at the lower edge of the previous pass.)

FIGURE 1-10



Adapted with permission of Binks Manufacturing Company

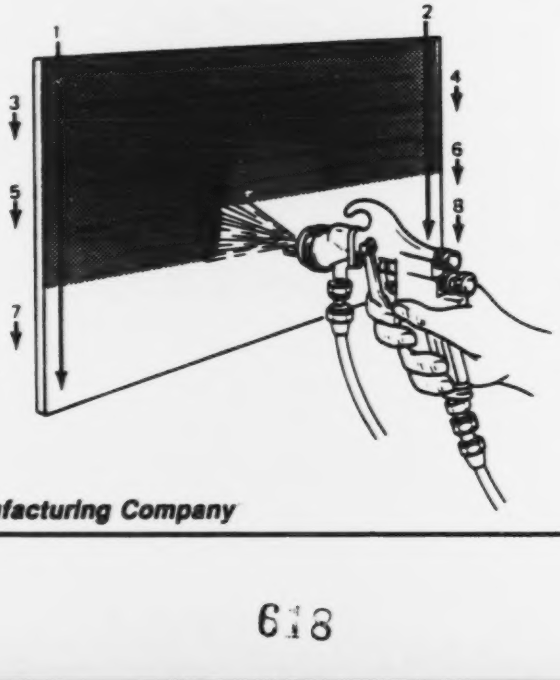
i. Continue to bottom of panel. (On last pass, lower half of spray pattern should be spraying off of the panel.)

2. To insure even coverage of ends, banding is recommended (FIG. 1-11)

   a. Each edge of panel is sprayed first with a vertical stroke

   b. In banding, the horizontal passes are ended before the end of the panel

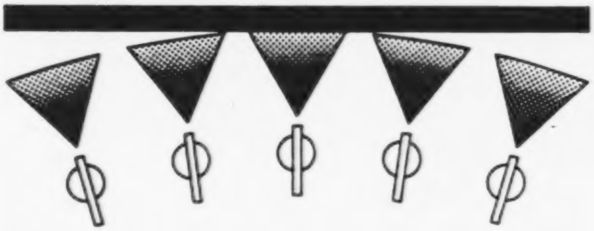
FIGURE 1-11



Courtesy of Binks Manufacturing Company

3. In spot repair, the gun is allowed to arc to allow blending of the spot repair into the original finish (FIG. 1-12)

FIGURE 1-12

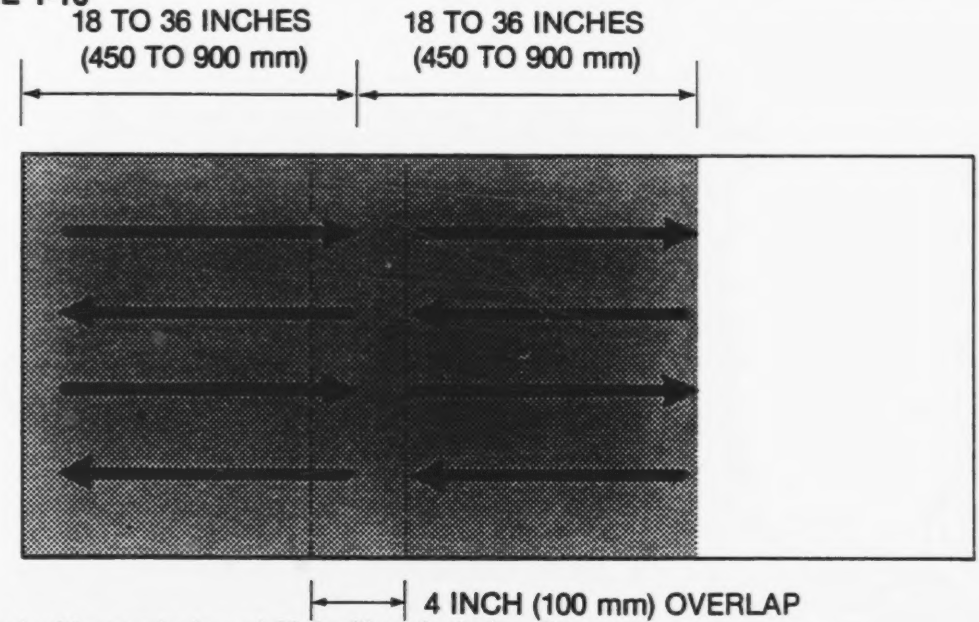


Courtesy of E. I. du Pont

4. If panel to be painted is longer than 36 inches, then panel should be divided into partial passes, using the following pattern: (FIG. 1-13)

   (NOTE: The trigger is released in the overlap areas, just as if coming to the end of a panel.)

FIGURE 1-13


18 TO 36 INCHES
(450 TO 900 mm)
18 TO 36 INCHES
(450 TO 900 mm)
4 INCH (100 mm) OVERLAP

Adapted with permission of Binks Manufacturing Company

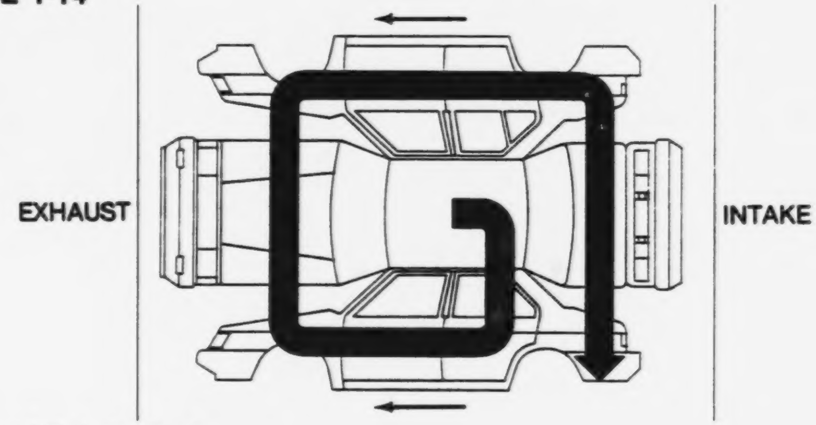
F. Complete refinishing

1. Complete refinishing requires spraying the panels in the correct sequence.
2. Purpose is to minimize overspray on previously painted surfaces

3. Manufacturer's recommendations for paint booth should be followed.

4. Pattern for downdraft booth (FIG. 1-14)

FIGURE 1-14



Courtesy of E. I. du Pont

III. Troubleshooting spray gun problems

A. Spitting - causes

1. Running out of paint
2. Tilting gun, allowing air to enter suction tube, or tilting gun and allowing paint to clog air vent
3. Loose or cracked fluid tube
4. Loose cup lid
5. Dry packing in gun
6. Loose fluid-needle-packing nut
7. Material too thick to flow freely
8. Material not properly strained and particles clogging fluid-needle valve.

B. Rough, dry and lusterless appearance

1. Fluid-adjustment screw not opened enough
2. Gun held too far from panel
3. Paint too thin

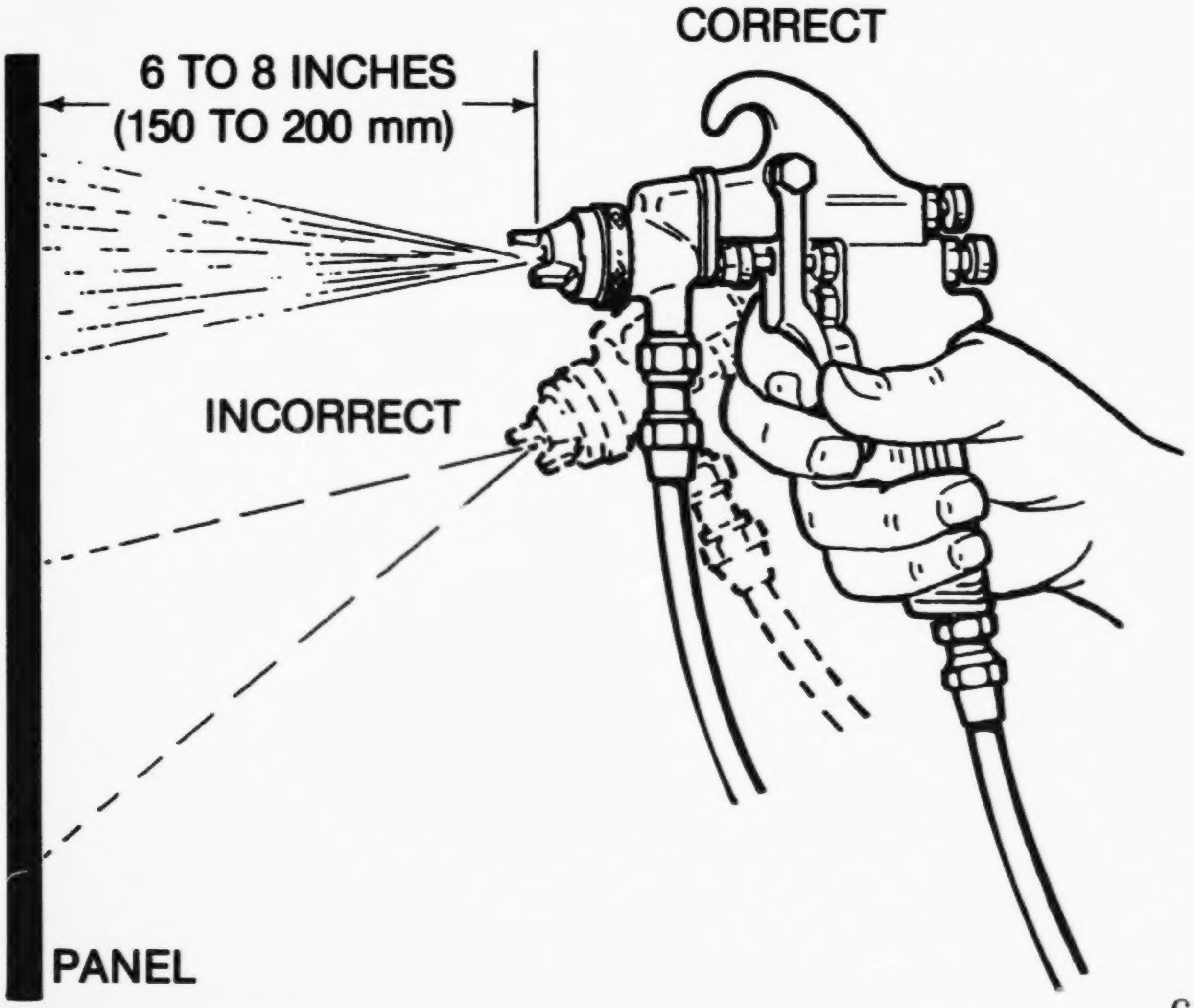
4. Too much air
5. Gun moving too fast
6. Not enough overlap on passes
7. Viscosity of paint too high

C. Too heavy coating with sags or ripples

1. Dirty air nozzle
2. Gun held too close to panel
3. Paint too thin or too thick
4. Low air pressure
5. Stroke too slow
6. Too much overlap on passes
7. Viscosity of paint too low

(NOTE: Other conditions, not related to the spray gun may cause application problems. These are covered in other lessons.)

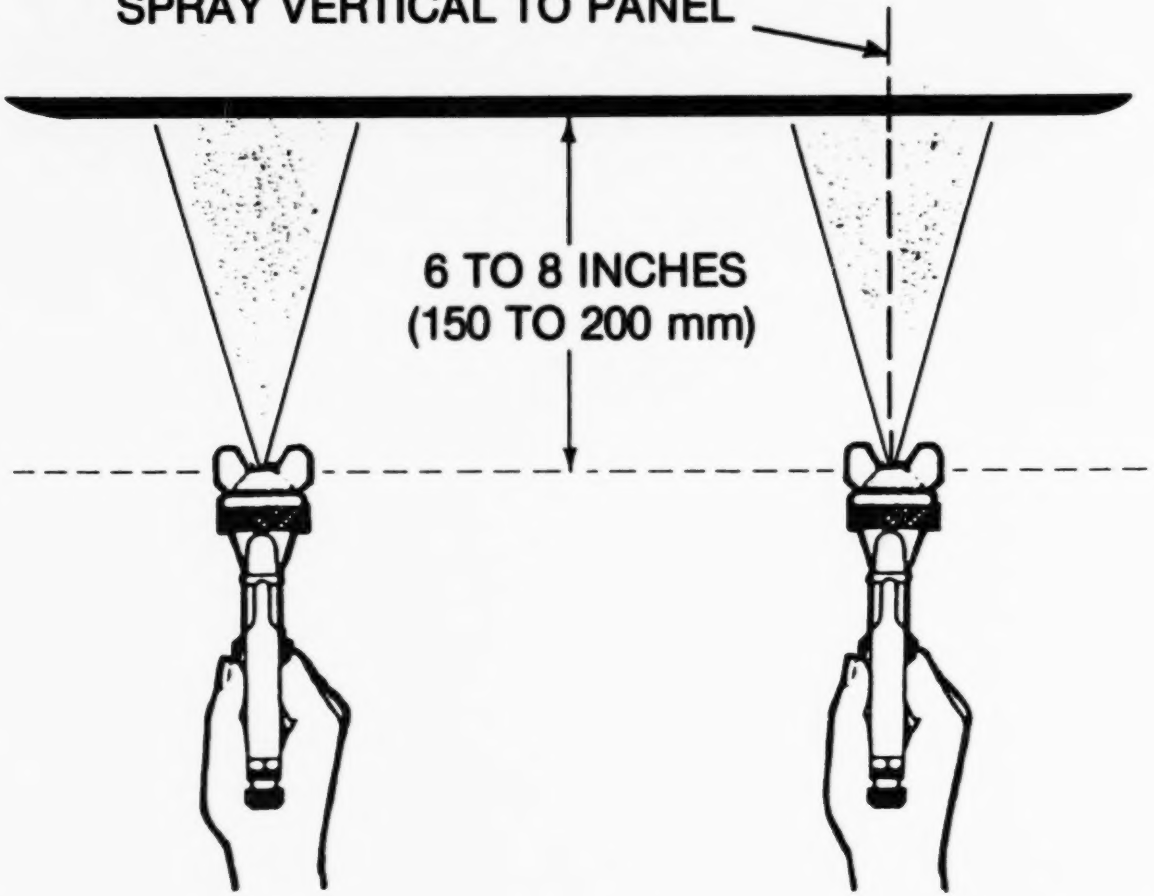
Correct Spraying Techniques


CORRECT
6 TO 8 INCHES
(150 TO 200 mm)
INCORRECT
PANEL

Adapted with permission of Binks Manufacturing Company

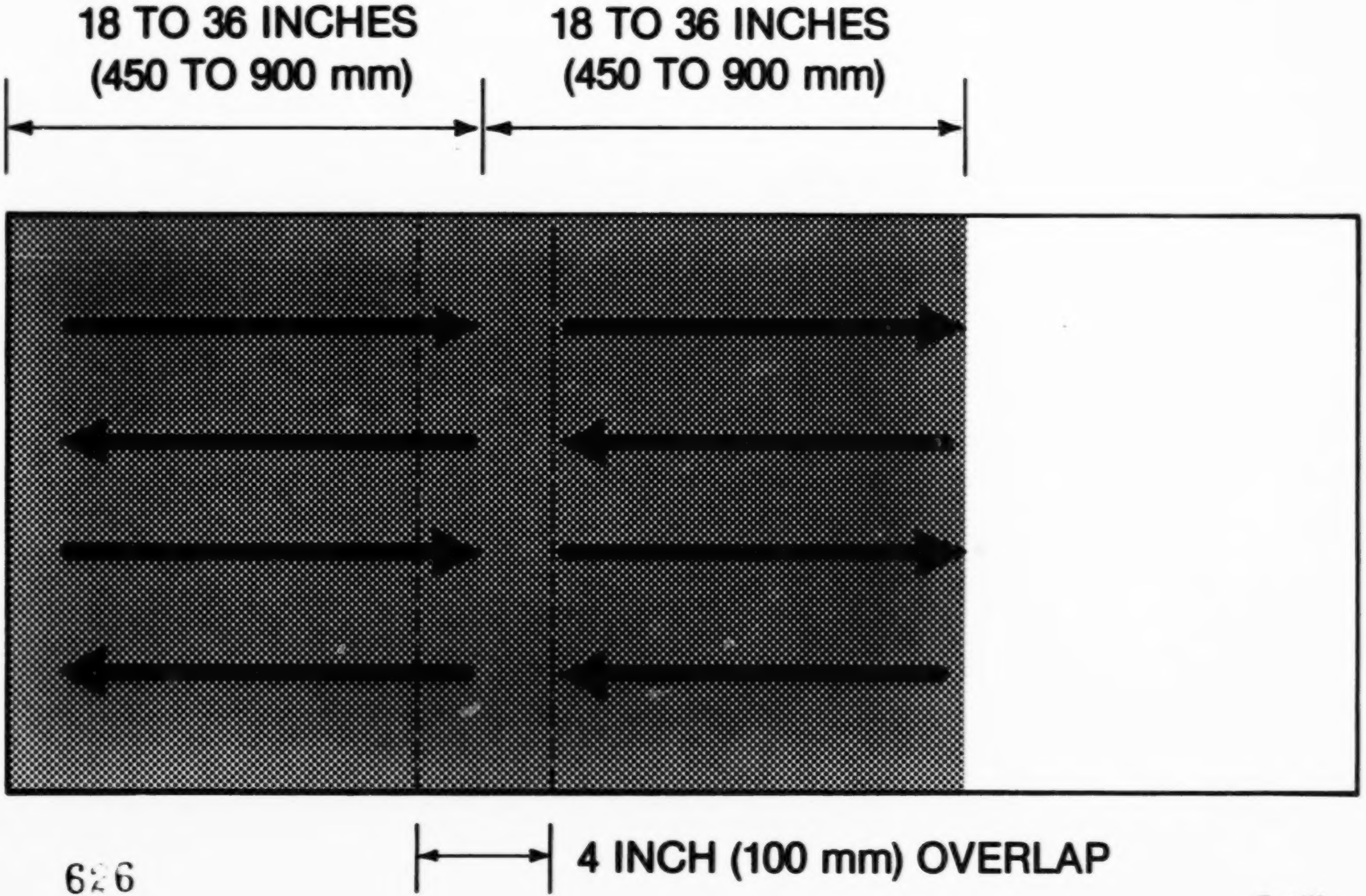
TM 1

Correct Spraying Techniques


SPRAY VERTICAL TO PANEL
6 TO 8 INCHES
(150 TO 200 mm)

Adapted with permission of Binks Manufacturing Company

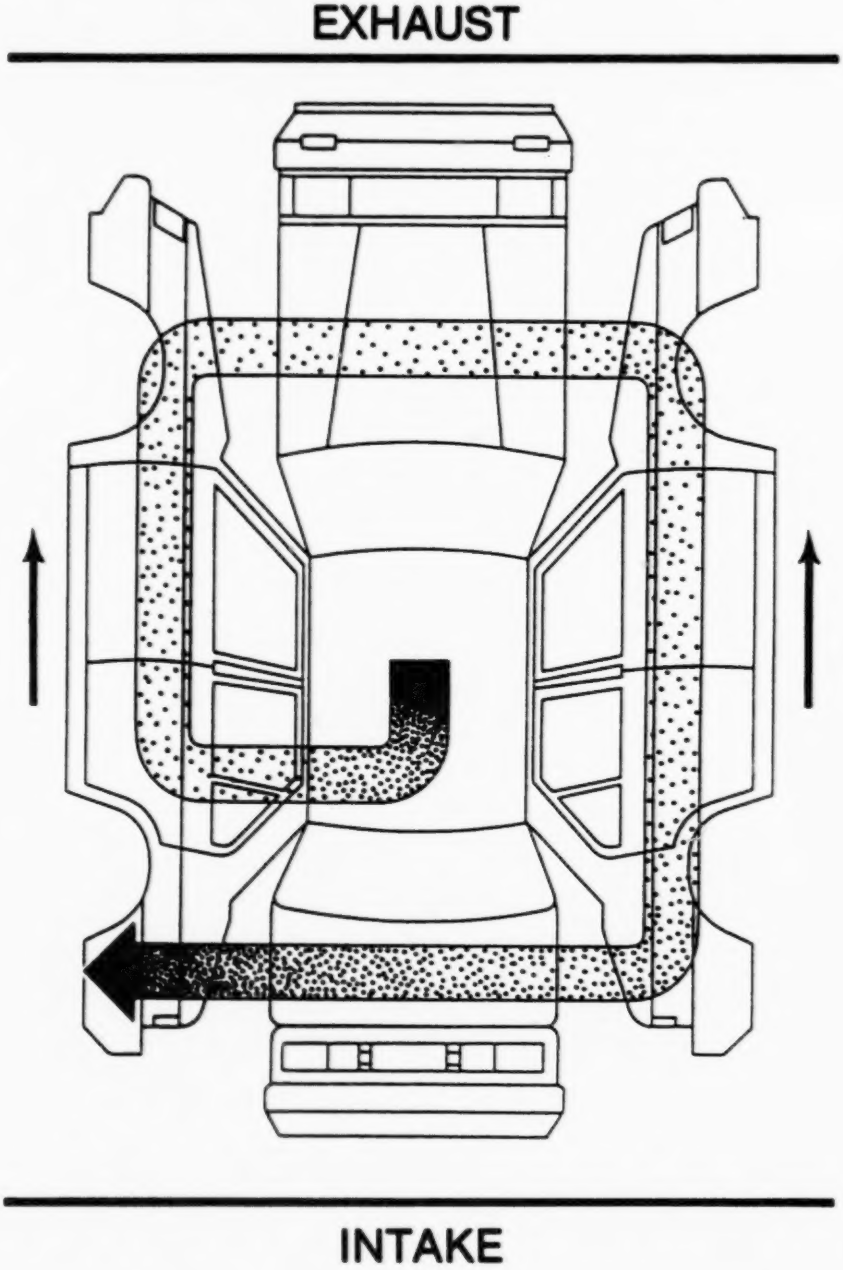
Correct Spraying Techniques


18 TO 36 INCHES
(450 TO 900 mm)
18 TO 36 INCHES
(450 TO 900 mm)
4 INCH (100 mm) OVERLAP

TM 3

Adapted with permission of Binks Manufacturing Company

Correct Spraying Techniques


EXHAUST
INTAKE

Courtesy of E. I. du Pont

UNIT II

JOB SHEET #1, LESSON ONE

USE THE PAINT GUN WITH PROPER TECHNIQUE

Equipment:

OEM paint
Proper primer
Proper thinner/reducer
Viscosity cup
Watch with seconds reading
Test panel
Paint paddle
Paint strainer
Masking tape
Sandpaper
Spray gun
Proper safety equipment

Procedure:

Evaluation:
3 2 1 N

1. Prepare panel for topcoat following paint manufacturer's recommendations. ___ ___ ___ ___

2. Place strainer in spray siphon cup or on strainer stand and pour paint through strainer into siphon cup. ___ ___ ___ ___

3. Attach cup and hose to spray gun and set air pressure at gun as recommended by paint manufacturer. ___ ___ ___ ___

   (NOTE: Air pressure drops as soon as the gun is triggered. The pressure must be set with the gun triggered.)

4. Set fan adjustment. ___ ___ ___ ___

   (NOTE: Set fan adjustment wide open and adjust downward until spray is correct.)

5. Test fan spray on scrap panel. Correct setting for most applications will have a pattern about 8 to 10 inches long and 2 to 3 inches wide when sprayed from a distance of about 8 inches. ___ ___ ___ ___

Procedure:

Evaluation:
3 2 1 N

6. Set fluid adjustment. ___ ___ ___ ___

   (NOTE: Most applications call for maximum fluid adjustment. Turn screw counterclockwise until one thread is visible.)

7. Test fluid adjustment by spraying on scrap panel and make adjustments as necessary. ___ ___ ___ ___

   (NOTE: Examine texture of spray. If rough, dry, or thin, adjust air-pressure screw or fluid-adjustment screw until proper texture is obtained.)

8. Apply top coat to test panel using following procedure: ___ ___ ___ ___
   a. Start in upper right corner so that spray starts just off of panel.
   b. Use even, level stroke, about one foot per second.
   c. Release trigger enough to stop paint flow at end of each pass.
   d. Use banding of panel edges.
   e. Use 50 percent overlap technique.
   f. Apply according to paint manufacturer's recommendations.

9. Apply additional coats as recommended. ___ ___ ___ ___

   (NOTE: Always clean paint gun immediately after use.)

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for competency L3 "Use the paint gun with proper technique.")

UNIT II

JOB SHEET #2, LESSON ONE

SERVICE AND MAINTAIN A SPRAY GUN

Equipment:

Siphon-feed paint gun
Proper solvent
Clean, absorbent, white cloths
Wooden toothpick
Recommended lubricant
Respirator
Eye protection and rubber gloves

Procedure: **Evaluation:**
3 2 1 N

1. Put on safety equipment and remove paint from gun by the following procedure: ___ ___ ___ ___
    a. Loosen cup from gun and raise gun, holding end of fluid line over cup.
    b. Unscrew air cap two or three turns.
    c. Hold cloth over air cap and pull trigger on gun to force paint in gun back into cup.
    d. Remove cup from gun and pour contents into waste paint can.
2. Rinse cup with recommended solvent and discard solvent in proper container after cup is clean. ___ ___ ___ ___
3. Refill siphon cup one-third full of solvent and clean internal gun parts with the following method:
    a. Turn regulator to 15 psi.
    b. Tighten air cap and spray solvent through the system in well-ventilated area while adjusting fluid volume to wide-open.
    c. Hold white rag over nozzle and pull trigger to force paint down into cup.
    d. Repeat steps a, b and c, if needed, as many times as needed. ___ ___ ___ ___

	Procedure:	**Evaluation:** 3	2	1	N
4.	Remove air cap from gun and clean in solvent, blowing off with compressed air. Inspect all orifices and if necessary clean with a wooden toothpick.	___	___	___	___
	(NOTE: Never use a metal wire, welder tip cleaner or other metal object to clean spray equipment.)				
5.	Loosen material adjustment screw, remove needle and clean in solvent.	___	___	___	___
6.	Inspect fluid nozzle and wipe with a solvent soaked cloth.	___	___	___	___
7.	Replace all removed parts and wipe gun with a solvent-soaked cloth.	___	___	___	___
8.	Clean gun internally by repeating step 3.	___	___	___	___
9.	Lubricate gun with recommended lubricant	___	___	___	___
	(CAUTION: *Do not use a lubricant containing silicone. If silicone gets into the spray gun or hose, it cannot be completely flushed out.)*				
10.	Use recommended lubricant on fluid-needle packing, air-valve packing, side-port control packing, and trigger pivot points. Then coat needle-valve spring with petroleum jelly.	___	___	___	___
11.	Wipe down all hoses and the exterior of the gun with a solvent-soaked cloth, then fill gun with about one inch of solvent and store properly.	___	___	___	___
	Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency L4 "Service and maintain a paint gun.")

UNIT II

JOB SHEET #3, LESSON ONE

SERVICE AND MAINTAIN THE PAINT ROOM

Equipment:

Proper solvent
Clean, absorbent, white cloth
Respirator
Eye protection
Rubber gloves
Glass cleaner
Air gun
Broom and dustpan
Screwdriver
Replacement lights, if needed
Sealing strips for door or filters, if needed
Replacement filters
Replacement paint arresters

Procedure:	**Evaluation:** 3	2	1	N
1. Clean lights according to instructor's directions.	___	___	___	___
2. Change paint arresters as needed.	___	___	___	___
3. Blow down arresters and entire booth with blow gun, then sweep area clean and carefully discard refuse.	___	___	___	___
4. Change paint booth filters, according to instructor's directions and check to see that filter access doors are sealing properly.	___	___	___	___
5. Check seal around door and replace any damaged sealing strips.	___	___	___	___
6. Perform any maintenance of exhaust or heating systems recommended by booth manufacturer.	___	___	___	___
7. Scrub down booth with recommended solution and allow to dry.	___	___	___	___
8. Shut up paint booth, turn on paint booth exhaust system and use air gun to blow clean all areas of paint booth so that any remaining fine dust will be blown through paint arresters in exhaust system.	___	___	___	___

Procedure:	**Evaluation:** 3	2	1	N
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency L5 "Service and maintain the paint room.")

MODULE: PAINT AND REFINISHING

UNIT II: SPRAYING TECHNIQUES

UNIT II TEST

I. Select the best answer from the five choices listed.

_____1. In spraying operations it is important that air pressure is measured: (a) with a regulator, (b) with an approved gauge, (c) according to manufacturer's recommendations, (d) at the gun, (e) in psi.

_____2. For complete panel repairs the fan-adjustment screw should be set: (a) wide open, (b) less than wide open, (c) one turn under wide open, (d) half open, (e) open until one thread appears.

_____3. For spot repairs, the fan-adjustment screw should be set: (a) wide open, (b) less than wide open, (c) one turn under wide open, (d) half open, (e) open until one thread appears.

_____4. For most applications, you set the fluid-adjustment screw: (a) wide open, (b) less than wide open (c) one turn under wide open, (d) half open, (e) open until one thread appears.

_____5. For paint patterns that are top heavy, bottom heavy, or heavy on the right or left side, a common cause is: (a) horn holes partially clogged, (b) incorrect paint reduction, (c) incorrect spray adjustment, (d) incorrect fluid adjustment, (e) incorrect air pressure.

_____6. For paint patterns which are heavy in the center, which of the following is NOT a common cause: (a) too low of setting on the fan adjustment, (b) paint too thick, (c) tilting gun, (d) nozzle too large or too small for material, (e) too much air pressure.

_____7. For paint patterns which show a split spray, which of the following is a common cause: (a) fan adjustment too high, (b) too high of fluid adjustment, (c) holding gun too far away, (d) nozzle too large or too small for material, (e) paint too thin.

_____8. The proper distance to hold the gun from the panel in lacquer applications is: (a) 4 to 6 inches, (b) 6 to 8 inches, (c) 8 to 10 inches, (d) 10 to 12 inches, (e) varies with paint manufacturer.

_____9. The proper distance to hold the gun from the panel in enamel applications is: (a) 4 to 6 inches, (b) 6 to 8 inches, (c) 8 to 10 inches, (d) 10 to 12 inches, (e) varies with paint manufacturer.

_____10. The height of a proper spray pattern should be: (a) 4 to 6 inches, (b) 6 to 8 inches, (c) 8 to 10 inches, (d) 10 to 12 inches, (e) varies with paint manufacturer.

_____11. The width of a proper spray pattern should be: (a) 2-3 inches, (b) 4 to 6 inches, (c) 6 to 8 inches, (d) 8 to 10 inches, (e) varies with paint manufacturer.

_____12. If the coating of paint is too dry, you first should try to: (a) decrease air pressure by 5 psi, (b) increase air pressure by 5 psi, (c) open fan adjustment wider, (d) close fan adjustment, (e) move gun faster.

_____13. If the coating of paint is too wet you should first try to: (a) decrease air pressure by 5 psi, (b) increase air pressure by 5 psi, (c) open fan adjustment wider, (d) close fan adjustment, (e) move gun faster.

II. Mark a T on the test or answer sheet if the statement is true and an F if the statement is false.

_____14. Spot repair requires more air pressure than other repairs.

_____15. Metallic polyurethane paints require a high air pressure of 65 psi.

_____16. Complete panel refinishing may be done in the case of a new panel or in a case where spot repairs are needed on two or more areas of the panel.

_____17. Complete refinishing is done when the old paint is in bad condition.

_____18. Recommended air pressure will vary with the type of paint used.

_____19. Air pressure is controlled by the pressure gauge.

_____20. In proper spraying technique, you should hold the gun level and at right angles to the panel.

_____21. In proper spraying technique, you should move the gun approximately one foot per second.

_____22. You should start painting at the top center of the panel to be painted.

_____23. The maximum length of strokes when spray painting should be about 12 to 24 inches.

_____24. When you are spraying, each stroke should overlap the previous stroke by 25 percent.

_____25. You should never spray in such a way that part of the spray is spraying off of the panel being painted because this produces too much overspray.

_____26. Banding is a practice done by spraying the vertical edges of panels first, using a vertical stroke.

_____27. You must never allow the gun to arc in any circumstances.

_____28. The purpose of following a pattern for complete refinishing is to minimize overspray.

III. For the paint problem causes listed in questions 29 through 37, select what result the problem would likely cause from the list below.

A. Spitting
B. Rough, dry appearance
C. Sags or ripples

_____29. Running out of paint

_____30. Moving gun too fast

_____31. Loose gun cup

_____32. Moving gun too slowly

_____33. Too much overlap on passes

_____34. Material not properly strained

_____35. Low air pressure

_____36. High air pressure

_____37. Gun held too far from panel

(NOTE: Successful completion of this unit test with a minimum score of _____ is necessary for the student to receive an evaluation on Job Sheet #1, this unit.)

ANSWERS TO UNIT II TEST

1. D
2. A
3. B
4. E
5. A
6. C
7. A
8. B
9. C
10. C
11. A
12. A
13. B

14. F
15. T
16. T
17. T
18. T
19. F
20. T
21. T
22. F
23. F
24. F
25. F
26. T
27. F
28. T

29. A
30. B
31. A
32. C
33. C
34. A
35. C
36. B
37. B

MODULE: PAINT AND REFINISHING

UNIT III: SURFACE PREPARATION AND UNDERCOATS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify and use proper surface preparation techniques and identify and use undercoating materials. Mastery will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Match terms with their definitions (Competency M1, Unit III test)

II. Identify surface preparation equipment and basic paint removal methods (Competency M1, Unit III test)

III. Identify sanding, metal conditioning, and masking procedures (Competency M1, Unit III test)

IV. Demonstrate the ability to:

  a. Strip painted surfaces using chemicals (Competency M2, Job Sheet #1)

  b. Mask for a panel repair (Competency M3, Job Sheet #2)

  c. Mask a vehicle for a complete paint job (Competency M3, Job Sheet #3)

  d. Mask for a urethane primer (Competency M3, Job Sheet #4)

  e. Prepare surface of new panel (Competency M4, Job Sheet #5)

  f. Prepare surface of damaged panel (Competency M5, Job Sheet #6)

  g. Sand for a complete paint job (Competency M5, Job Sheet #7)

  h. Demonstrate appropriate sanding techniques (Competency M6, Job Sheet #8)

Lesson 2:

I. Match terms with their definitions (Competency M1, Unit III test)

II. Identify basic paint undercoats (Competency M1, Unit III test)

III. Identity proper undercoat application techniques (Competency M1, Unit III test)

IV. Demonstrate the ability to:

  a. Select and apply appropriate primer, guide coat, and sealer (Competencies M7 and M8, Job Sheet #1)

MODULE: PAINT AND REFINISHING

UNIT III: SURFACE PREPARATION AND UNDERCOATS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. References

D. Lesson plans

   1. Lesson 1: Preparing Surfaces for Paint

      a. Information outline

      b. Transparency masters

         TM#1: Featheredging

      c. Job sheets

         JS#1: Strip painted surfaces using chemicals
         JS#2: Mask for a panel repair
         JS#3: Mask a vehicle for a complete paint job
         JS#4: Mask for a urethane primer
         JS#5: Prepare surface of new panel
         JS#6: Prepare surface of damaged panel
         JS#7: Sand for a complete paint job
         JS#8: Demonstrate appropriate sanding techniques

   2. Lesson 2: Undercoats

      a. Information outline

      b. Job Sheets

         JS#1: Select and apply appropriate primer, guide coat and sealer

E. Unit test

F. Answers to unit test

REFERENCES USED IN WRITING THIS UNIT

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2. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

3. Czapskie, George S., et. al. *Auto Body Repair.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1977.

4. The DeVilbiss Company. *The ABC's of Spray Equipment for Refinishing*. The DeVilbiss Company. Toledo, OH. 1981.

5. du Pont, E.I. *Auto Refinishing Handbook*. E.I. du Pont de Nemours & Co. Wilmington, DE. 1985.

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8. Miller Electric Mfg. Co. *Fundamentals of Gas Metal-Arc (MIG) Welding*. Appleton, WI. N.D.

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MODULE: PAINT AND REFINISHING

UNIT III: SURFACE PREPARATION AND UNDERCOATS

LESSON ONE: PREPARING SURFACES FOR PAINT

I. **Terms and definitions**

A. Apron -- Paper with masking tape at one edge used to mask large areas against overspray.

B. Apron taper -- Masking paper dispenser that applies tape to edge of paper as the paper is pulled from the roll.

C. Back-sanding -- Sanding the area beyond the featheredge area when preparing for a primer-surfacer application.

D. Chemical stripper -- Any caustic material used to remove a painted surface to the bare metal.

E. Featheredging -- Using sandpaper to taper a broken paint edge from bare metal to the top of the remaining paint film so that the depression in the paint is not noticeable. The tapered edge is called the featheredge.

F. Grit -- The abrasive coating on sandpaper. The higher the number, the finer the grit.

G. Hot spot -- A spot where paint has failed due to a chemical stripper not being neutralized or completely removed from the vehicle surface before painting.

H. Masking -- Applying masking paper and/or tape to shield areas on a vehicle which are not to be painted.

I. Masking paper -- A specially designed paper which prevents paint from bleeding through.

J. Masking tape -- Adhesive strips of varying widths specially designed for masking of vehicles during refinishing.

K. Overspray -- An overlap of dry spray gun paint particles on areas that were not meant to be painted.

L. Sandblasting -- Using a special machine that directs a stream of sand or other abrasive material under high pressure to remove paint and expose bare metal.

M. Sand scratches -- Marks left in metal or old finish by sanding operations which may show through unless properly prepared.

N. Scuff-sanding -- Using very fine sandpaper to lightly sand painted surfaces which are otherwise ready for paint.

O. Wet-or-dry abrasive -- A type of sandpaper that can be applied either dry or with water.

II. Surface preparation equipment and paint removal methods

A. Equipment

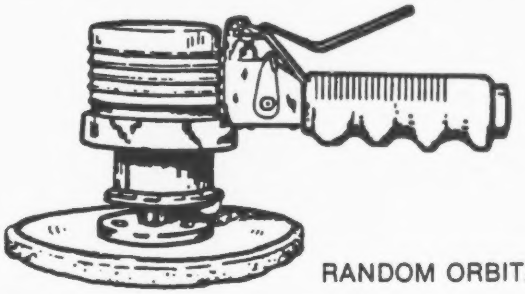
1. Apron taper -- Masking paper dispenser which applies tape to edge of paper as the paper is pulled from the roll.

2. Blow gun -- Nozzle attached to air compressor hose and used to blow dust and dirt from cracks and from the surface of a vehicle.

3. Buffer -- Power tool with a rotating disk used to apply rubbing compound.

4. Random orbital sander -- Power tool with rotating disk that moves with an eccentric (off-center) motion, used to smooth metal and to sand and featheredge paint. (FIG. 1-1)

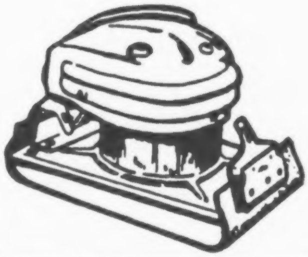
FIGURE 1-1



RANDOM ORBITAL SANDER

5. Orbital-reciprocating sander -- Power tool which moves with a rapid back-and-forth motion used to smooth metal, and to sand and featheredge paint. (FIG.

FIGURE 1-2



RECIPROCATING SANDER

6. Oscillating sander -- Term which may refer to any orbital or reciprocating sander.

7. Sanding block -- Block to which sandpaper is attached so that the pressure of a hand-sanding operation is distributed evenly.

8. Sandpaper -- A heavy paper specially coated with abrasive material for removing surface imperfections in paint and metal.

9. Tack rag -- A cheesecloth pad soaked in a sticky, non-drying varnish, used to pick up lint, dust and dirt from a surface to be painted.

B. Methods of removing paint

1. Sandblasting

   a. Seldom used in modern auto body work

   b. Does excellent job of removing paint, but can damage plastic, chrome or rubber surfaces

2. Chemical stripping

   a. Should be used only on metal

   b. Should be used only if entire panel or vehicle is to be refinished

   c. Should be used only in cases where the finish is badly weathered or cracked, or the undercoat is in poor condition.

   d. Should be used on only about a one-foot-square area at a time

   e. Be sure to follow stripper manufacturer's recommendations closely.

   f. Wear protective clothing, rubber gloves, a respirator and eye protection.

   g. Keep a supply of fresh water available to wash away or dilute the chemical in case of an emergency.

   h. Work in a well-ventilated area.

3. Grinding and sanding

   a. Most common methods of paint removal

   b. Grinding disk may be used to remove paint completely from large areas, but an orbital or reciprocating sander, or hand sanding, is recommended to prepare surfaces for painting

   c. Sanding may be either wet or dry

III. Sanding, metal conditioning and masking

A. Reasons for sanding

1. Remove defective paint

2. Provide microscopically roughed surface for adhesion

3. Provide a smooth surface for new paint, removing scratches, nicks and foreign particles

B. Types of sanding operations

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1. Orbital or reciprocating sanding -- Used to prepare surfaces for paint after damage has been repaired. May be used for all hand sanding operations (with proper technique) although hand sanding may be preferred.

2. Hand sanding -- Most final sanding operations are done by hand.

C. Types of hand sanding

1. Bare metal sanding

    a. Use coarse paper if there are burrs

    b. Use fine paper if metal is smooth

2. Thorough sanding

    a. Done when old finish is rough or in poor condition

    b. Done to level and smooth primer-surfacer

3. Light sanding (scuff-sanding)

    a. Done when old finish is in good condition

    b. Purpose is to improve adhesion only

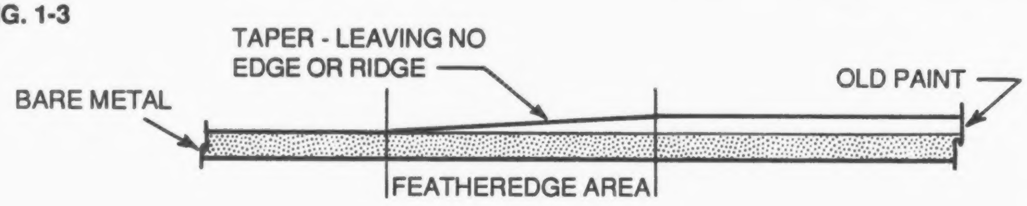
4. Featheredging

    a. Sanding operation done to prevent broken edge from showing through new paint.

    b. Must be done with fine-grit sandpaper.

    c. Done is such a way that the old paint tapers from full thickness to zero thickness, with the tapered area long enough that the difference in thicknesses cannot be noticed. (FIG. 1-3)

FIG. 1-3



D. Wet sanding versus dry sanding

  1. Wet sanding

    a. Done to prevent sand paper from clogging

    b. Washes away sanding residue that could cause scratches

    c. Allows surface to be checked as it is continually rinsed

  2. Dry sanding

    a. Faster than wet sanding

    b. Does not wet masking paper or tape which could require re-masking

    c. Clean up is easier and there is no wet floor, which may be a safety concern

E. Hand sanding guidelines

  1. Do not sand in the spray booth

  2. Use a sanding block

  3. Do not apply too much pressure

  4. Always sand in a straight line

F. Using metal conditioner

  1. All bare metal should be treated with metal conditioner and conversion coating prior to the application of a primer.

  2. Metal conditioners remove microscopic corrosion.

  3. Safety is important when working with metal conditioners and conversion coatings. Use protective clothing, rubber gloves, and eye protection.

  4. After applying metal conditioner, a thorough washing and drying is required. Primer should be applied as soon after as possible to guard against contamination.

  (NOTE: A recent development is the self-etching primer, which eliminates the need for metal conditioner and conversion coating. Self-etching primers are currently gaining acceptance and may become universally approved for use.)

G. Using conversion coatings

  1. Applied after metal conditioner

  2. Chemically coats metal surface to provide the proper paint-binding surface

  3. Acts to inhibit rust and corrosion

4. Should be applied following directions on label.
    a. Allow to remain on surface for two to five minutes
    b. Rinse with cold water or wipe with damp sponge or cloth
    c. Wipe surface dry with clean cloths
    d. May cause metal to turn color, but this is normal

H. Masking

1. The purpose of masking is to keep paint off of areas of the vehicle that are not to receive paint, such as windows, trim and tires.
2. Use widest masking paper available to reduce the time required to do the job
3. When masking large areas requiring two sheets of paper, be sure that top piece of paper overlaps bottom piece
4. Use tape and paper to mask taillights and areas around them thoroughly, or use plastic light covers.
5. Tape and paper should completely cover surface to be protected without touching any surface to be painted
6. Do not apply to wet or dirty surfaces -- tape will not stick
7. Tape should not be stretched or it will shrink back and expose an area that should not be exposed
8. When spraying a horizontal surface, prevent bleeding through the tape by using two layers of paper or reverse taping procedure, where paper is taped on the inside and allowed to bellow out away from the surface
9. Vehicle surface temperature should be at least 60° F
10. When spraying door jambs, sills, and pillars, tape the door opening thoroughly to prevent overspray from hitting interior components
11. Fold and tape any pleats in the paper to prevent sanding dust from collecting in them
12. Store tape in a cool place - heat will damage it
13. When masking for a urethane primer, double-tape all edges and use double thicknesses of masking paper

    (NOTE: Urethane primer bleeds easily through masking tape.)

I. Guidelines for removing masking paper and tape

1. Remove well before paint has completely dried.

2. Test paint by touching fresh paint on masking tape. If tape is slightly tacky the tape can be removed.

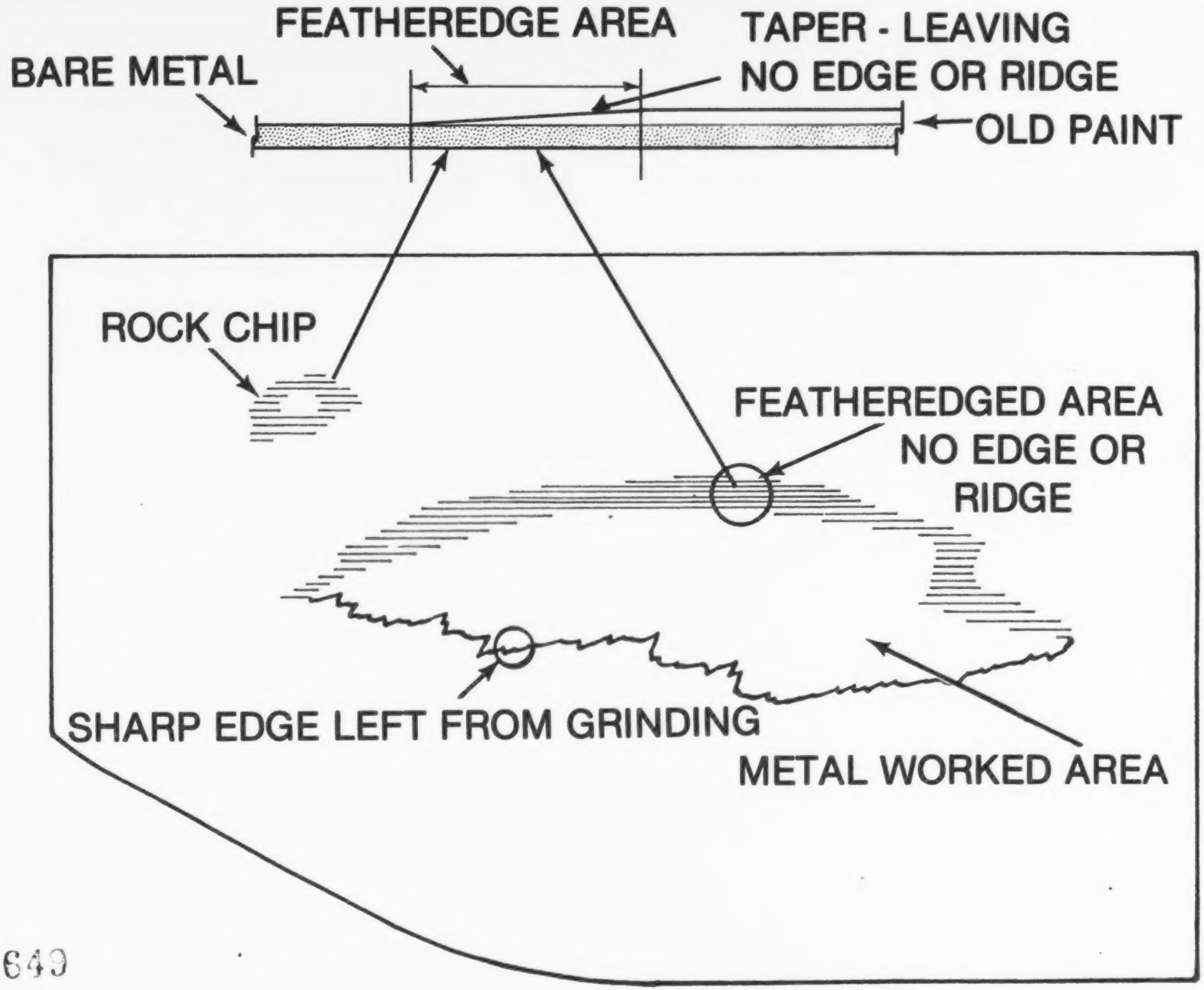
   (**CAUTION:** *Consult paint manufacturer's recommendations for taping and tape removal procedures.)*

3. Remove tape by pulling straight out from surface, maintaining a 90-degree angle as tape is removed.

J. Sequence of steps in painting a vehicle

1. Make panel and frame repairs.
2. Fill sheet metal with plastic filler and smooth out.
3. Wipe off dust and blow dust out of crevices with compressed air.
4. Wash and dry vehicle.
5. Mask vehicle.
6. Wipe down area to be painted with clean lint-free paper towels and a tack rag.
7. Treat bare metal with metal conditioner and conversion coating.
8. Spray on primer-surfacer.
9. Sand primer-surfacer.
10. Spray on and sand guide coat.
11. Apply scratch putty and re-prime and re-sand surface as necessary.
12. Wash repaired areas with water and detergent and re-mask if necessary.
13. Spray on adhesion promoter, if used.
14. Spray on sealer, if used.
15. Spray on chip-resistant coating, if used.
16. Spray on color coats.
17. Spray on clearcoat, if used.

Featheredge


FEATHEREDGE AREA
TAPER - LEAVING NO EDGE OR RIDGE
BARE METAL
OLD PAINT
ROCK CHIP
FEATHEREDGED AREA NO EDGE OR RIDGE
SHARP EDGE LEFT FROM GRINDING
METAL WORKED AREA

TM 1

UNIT III

JOB SHEET #1, LESSON ONE

STRIP PAINTED SURFACES USING CHEMICALS

Equipment:

Panel or vehicle to be stripped
Hand tools for trim removal
Masking tape
Detergent and water solution
Wax and grease remover
Brush
Chemical stripper
Sand paper
Oscillating sander
Protective clothing and equipment

Procedure:

Evaluation:
3 2 1 N

1. Wash vehicle with detergent and water. ___ ___ ___ ___
2. Remove moldings, emblems and trim. ___ ___ ___ ___
3. Clean entire surface to be stripped with wax and grease remover. ___ ___ ___ ___
4. Double mask all trim, moldings and emblems that cannot be removed. ___ ___ ___ ___
5. Put on protective clothing and equipment and apply stripper to a one-foot-square area with a brush. ___ ___ ___ ___
6. Remove the softened paint from the surface first using a putty knife, and then a wire brush. ___ ___ ___ ___
7. Wash entire surface with water. ___ ___ ___ ___

   (NOTE: Washing with water is necessary to neutralize the stripper. If stripper is left on surface it will cause hot spots where the paint will fail.)

8. Sand the surface, using an oscillating sander for large areas and hand-sanding around moldings, emblems and trim. ___ ___ ___ ___
9. Apply metal conditioner. ___ ___ ___ ___

Procedure:	**Evaluation:** 3	2	1	N
10. Prime panel.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency M2 "Strip painted surfaces using chemicals.")

UNIT III

JOB SHEET #2, LESSON ONE

MASK FOR A PANEL REPAIR

Equipment:

Vehicle
Masking tape of various widths
Masking paper
Cleaning materials
Clean, white rags or paper towels
Common hand tools
Sharp knife or razor blade
Clear lacquer and small paintbrush
Proper eye protection

Procedure:	**Evaluation:** 3	2	1	N
1. Put on eye protection and remove any trim that will not be masked.	___	___	___	___
2. Clean surfaces that will be masked and use blow gun to dry.	___	___	___	___
3. Use narrow masking tape to mask small emblems or lettering.	___	___	___	___
4. Use 3/4-inch tape to mask larger trim.	___	___	___	___
5. Use masking paper to mask large areas, such as windows or door openings.	___	___	___	___
6. Apply clear lacquer on any weatherstripping and allow to dry before applying masking tape to weatherstripping.	___	___	___	___
7. Mask panel along natural breaks.	___	___	___	___
8. Trim any excess tape.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is one of the evaluations which may be used as the evaluation for competency M3 "Demonstrate appropriate masking techniques.")

UNIT III

JOB SHEET #3, LESSON ONE

MASK A VEHICLE FOR A COMPLETE PAINT JOB

Equipment:

Vehicle
Masking tape of various widths
Masking paper
Plastic light covers for vehicle
Cleaning materials
Clean, white rags or paper towels
Common hand tools
Sharp knife or razor blade
Clear lacquer and small paintbrush
Proper eye protection

Procedure:		**Evaluation:**			
		3	**2**	**1**	**N**
1.	Put on eye protection and remove any trim that will not be masked.	___	___	___	___
2.	Clean surface of entire vehicle and use blow gun to dry.	___	___	___	___
3.	Use narrow masking tape to mask small emblems or lettering.	___	___	___	___
4.	Use 3/4-inch tape to mask larger trim.	___	___	___	___
5.	Use masking paper to mask large areas, such as windows or door openings.	___	___	___	___
6.	Apply clear lacquer on any weatherstripping and allow to dry before applying masking tape to weatherstripping.	___	___	___	___
7.	Mask lights using masking tape or light covers.	___	___	___	___
8.	Mask bumpers with masking paper.	___	___	___	___
9.	Trim any excess tape.	___	___	___	___
	Average of above evaluations*	___	___	___	___

(*This average is one of the evaluations which may be used as the evaluation for competency M3 "Demonstrate appropriate masking techniques.")

UNIT III

JOB SHEET #4, LESSON ONE

MASK FOR URETHANE PRIMER

Equipment:

Vehicle
Masking tape of various widths
Masking paper
Plastic light covers for vehicle
Cleaning materials
Clean, white rags or paper towels
Common hand tools
Sharp knife or razor blade
Clear lacquer and small paintbrush
Proper eye protection

Procedure: **Evaluation:**

		3	2	1	N
1.	Put on eye protection and remove any trim that will not be masked.	___	___	___	___
2.	Clean surface of entire vehicle and use blow gun to dry.	___	___	___	___
3.	Use narrow masking tape to mask small emblems or lettering, using double thicknesses of tape.	___	___	___	___
4.	Use 3/4-inch tape to mask larger trim, using double thicknesses of tape.	___	___	___	___
5.	Use masking paper to mask large areas, such as windows or door openings, using double thicknesses of tape and paper.	___	___	___	___
6.	Apply clear lacquer on any weatherstripping and allow to dry before applying masking tape to weatherstripping.	___	___	___	___
7.	Mask lights using masking tape or light covers. Double mask if using masking tape.	___	___	___	___
8.	Mask bumpers with masking paper, using double thicknesses of tape and paper.	___	___	___	___
9.	Trim any excess tape.	___	___	___	___
	Average of above evaluations*	___	___	___	___

(*This average is one of the evaluations which may be used as the evaluation for competency M3 "Demonstrate appropriate masking techniques.")

UNIT III

JOB SHEET #5, LESSON ONE

PREPARE SURFACE OF NEW PANEL

Equipment:

New replacement panel
Recommended sand paper and sanding block
Non-petroleum detergent
Wax and grease remover
Metal conditioner and conversion coating
Clean white rags
Eye protection
Recommended breathing equipment
Blow gun
Spray gun
Epoxy primer

Procedure:	**Evaluation:** 3	2	1	N
1. Wash panel with non-petroleum detergent, then wash with wax and grease remover.	___	___	___	___
2. Sand entire panel with sandpaper recommended by topcoat manufacturer.	___	___	___	___
3. If areas have been sanded through to bare metal, apply metal conditioners and conversion coating.	___	___	___	___
4. Apply epoxy primer to bare metal areas according to primer manufacturer's recommendations.	___	___	___	___
(NOTE: Almost all new replacement panels are coated at the factory with epoxy primer. DO NOT USE LACQUER PRIMER.)				
5. If minor imperfections are present, select and apply primer-surfacer by performing appropriate job sheet, in next lesson, this unit.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency M4 "Prepare surface new panel.")

UNIT III

JOB SHEET #6, LESSON ONE

PREPARE SURFACE OF DAMAGED PANEL

Equipment:

Vehicle with damaged panel
Recommended sand paper and sanding block
Scratch putty
Non-petroleum detergent
Final cleaner
Clean white rags
Eye protection
Recommended breathing equipment
Blow gun
Spray gun
Recommended primer
Wax and grease remover
Metal conditioner and conversion coating

Procedure:

	Evaluation:			
	3	**2**	**1**	**N**
1. Examine panel for condition of substrate.				
2. Wash panel with non-petroleum detergent then wash with wax and grease remover.				
3. Sand surface, as required.				
4. Apply metal conditioner and conversion coating to any bare metal.				
5. Apply scratch putty as needed and sand.				
6. Featheredge areas, as required.				
7. Prime surface by performing appropriate job sheet in Lesson 2, this unit.				
Average of above evaluations*				

(*This average is the evaluation for competency M5 "Prepare surface of damaged panel.")

UNIT III

JOB SHEET #7, LESSON ONE

SAND FOR A COMPLETE PAINT JOB (WET OR DRY)

Equipment:

Vehicle needing complete paint job
Recommended sand paper
Scratch putty
Sanding block
Non-petroleum detergent
Final cleaner
Clean white rags
Eye protection
Recommended breathing equipment
Blow gun
Spray gun
Recommended primer
Wax and grease remover
Metal conditioner and conversion coating
Masking tape
Masking paper
Light covers, if available

Procedure:

Evaluation:
3 2 1 N

1. Thoroughly wash vehicle, including underside, engine compartment, trunk compartment and door jambs. ___ ___ ___ ___

   (NOTE: Use a pressure washer for this procedure, if available.)

2. Rewash areas to be painted with non-petroleum detergent then wash areas to be painted with wax and grease remover. ___ ___ ___ ___

3. Remove or mask trim by performing Job Sheet #3, this lesson. ___ ___ ___ ___

4. Put on particle mask and eye protection and block-sand vehicle a section at a time. ___ ___ ___ ___

   (NOTE: Be careful to sand thoroughly around trim areas. Most paint failures will occur in these areas.)

5. Featheredge areas where required. ___ ___ ___ ___

6. Apply metal conditioner and conversion coating to any areas sanded to bare metal. ___ ___ ___ ___

Procedure:

Evaluation:
3 2 1 N

7. If color is to be changed, sand door jambs, trunk jamb, and other areas where color change will be noticeable. If color is to remain the same, scuff-sand only the exposed areas of jambs. ___ ___ ___ ___

8. Rewash sanded areas with non-petroleum detergent and water and re-mask if needed. ___ ___ ___ ___

9. Apply selected primer to required areas by performing appropriate job sheet in next lesson. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average may be used as the evaluation for competency M5 "Prepare surface of damaged panel.")

UNIT III

JOB SHEET #8, LESSON ONE

DEMONSTRATE APPROPRIATE SANDING TECHNIQUES

Equipment:

Panel or vehicle needing to be sanded
Recommended sand paper
Sand block
Electric or pneumatic sanders, where appropriate

Procedure:

Evaluation:

	3	2	1	N
1. Sand plastic filler to proper contour.	___	___	___	___
2. Featheredge old substrate edges.	___	___	___	___
3. Back-sand area beyond substrate edges.	___	___	___	___
4. Sand areas needing light sanding with appropriate technique.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency M6, "Demonstrate appropriate sanding technique.")

MODULE: PAINT AND REFINISHING

UNIT III: SURFACE PREPARATION AND UNDERCOATS

LESSON TWO: UNDERCOATS

I. **Terms and definitions**

A. Adhesion -- Ability of one substance to stick to a different substance.

B. Adhesion promoter -- Sealer containing special properties that enhance adhesion.

C. Bleeding -- The act of a new color coat sinking through a primer material.

D. Final cleaner -- Fast-drying material used for cleaning rubbing compound oil, fingerprints, sanding dust, and sludge from surface just before application of topcoat.

E. Flash off -- Initial stage of paint drying time during which some of the solvent evaporates, dulling the paint from a very high gloss.

F. Guide coat -- A primer of a contrasting color sprayed over a sanded primer-surfacer. After guide coat is sanded, the contrasting colors reveal surface imperfections.

G. Hiding -- The degree to which a paint obscures what it is applied over.

H. Holdout -- The ability of a surface to keep the topcoat from bleeding.

I. Precleaner -- Wax and grease remover used to prepare vehicle surface for an undercoat.

J. Primer -- Undercoating material used to promote adhesion and prevent corrosion.

K. Primer-sealer -- Undercoating material used to cover primer or primer-surfacer in order to prevent bleed-through on some types of finishes.

L. Primer-surfacer -- Undercoating material used to fill scratches as well as promote adhesion and prevent corrosion.

M. Rubbing compound -- Abrasive paste that smooths and etches paint film of a final color coat and brings out a high gloss.

N. Scratch putty -- Thick primer-surfacer material used after priming to fill minor surface imperfections that were not filled with primer-surfacer.

O. Sand-scratch swelling -- Condition where the solvent in a new topcoat softens the edges of sand scratches in the old topcoat, making them swell.

P. Sealer -- Material applied over primer coats to protect the primer from the topcoat or vice versa.

Q. Settling -- The act of a primer-surfacer separating into its different components and not spreading uniformly.

R. Substrate -- The surface to be painted, which may include the old finish, unpainted surfaces, filled surfaces, primered surface, etc.

S. Undercoat -- Layers of paint material such as primer, primer-surfacer, and sealer used to provide a smooth, adhesive, properly sealed and corrosion-free base for color coats.

II. Types of undercoats

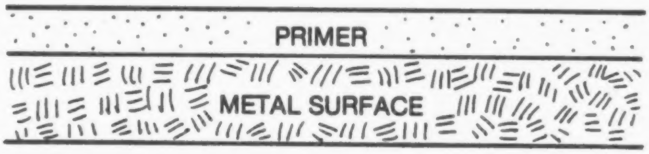
(NOTE: A variety of undercoating materials are on the market. Always use the primer materials recommended by the manufacturer of the topcoat you wish to apply.)

A. Precoats

1. Include metal conditioners and conversion coatings
2. Serve to condition metal and act like a primer for topcoat applications

B. Primers (FIG. 2-1)

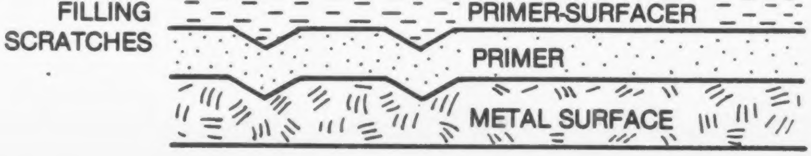
FIGURE 2-1



1. May be either lacquer-, enamel- or epoxy-type
2. Have no scratch-filling or sealing properties
3. Straight primer is seldom used in modern auto body repair

C. Primer-surfacers (FIG. 2-2)

FIGURE 2-2

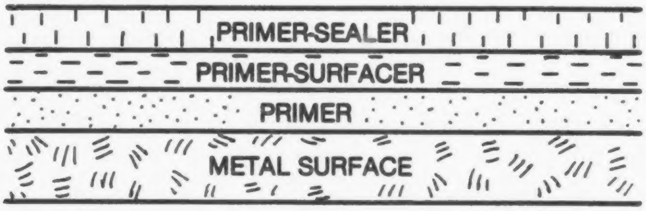


1. May be either lacquer or enamel
2. Use the one recommended for the substrate and topcoat with which you will be working
3. Thicker than primer, it will fill minor scratches

4. Requires sanding
5. Qualities of a good primer-surfacer
    a. Provides good adhesion
    b. Provides corrosion protection
    c. Fills minor surface imperfections
    d. Easily sanded
    e. Provides good holdout
    f. Fast drying

D. Primer-sealers (FIG. 2-3)

FIGURE 2-3



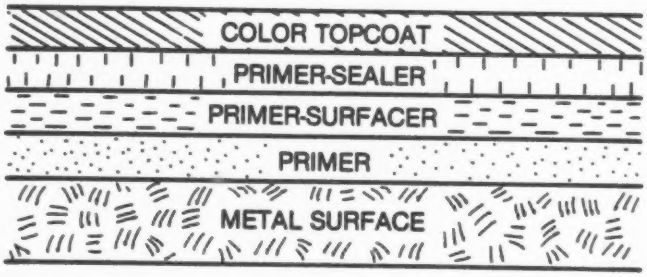
1. Used when recommended in order to prevent bleed-through of topcoat
2. Is advisable to use in most paint applications
3. Do not fill, but do not have to be sanded

E. Sealers

1. Help reduce sand-scratch swelling
2. Provide holdout
3. Make topcoat adhere better
4. Do not have to be sanded
5. Not recommended for use over bare metal

F. Typical undercoat/topcoat application (FIG. 2-4)

FIGURE 2-4



III. Undercoat application techniques

A. Factors to consider when choosing paint undercoats

(NOTE: Always follow the recommendations of the manufacturer of the topcoat you wish to apply.)

1. Type of surface
2. Condition of surface
3. Whether or not bleed-through is a potential problem
4. Type of topcoat to be used

B. Conditions requiring a sealer

1. Applying a light color over a dark color or a primer darker than the top coat
2. Certain combinations of old versus new topcoats (Table 1)

TABLE 1: Sealer Application to Improve Adhesion

Coat application	Sealer recommendation
Alkyd enamel over lacquer	Sealer must be used
Enamel over enamel	Adequate adhesion may be present between the two coats, but there is no guarantee, so sealer should be used
Lacquer over enamel	Spot repairs are not a problem, but a sealer is recommended, especially in panel repair or complete repainting
Lacquer over lacquer	Sealer is not required but may be desired for holdout and hiding sand scratches

C. Guidelines for quality undercoating

1. Read and follow all paint manufacturer's recommendations.
2. Never assume you know more than the paint manufacturer.
3. Check condition of old paint surface
    a. Check for rust.
    b. Sand through finish and featheredge a small area.
    c. If featheredge breaks, old surface must be thoroughly sanded or completely removed.
    d. If featheredge does not break, new topcoat can be applied after proper preparation.
4. Thoroughly remove all wax, grease or other contaminants.
5. Always use a sanding block when hand-sanding to avoid finger marks and uneven sanding, and always sand in the same direction.
6. Do not use petroleum-based detergents to wash vehicle.
7. Do not rub fingers over an area to determine the effects of sanding -- the skin oil from your hands will be transferred to the vehicle surface and can ruin the paint job.
8. Do not primer over bare metal that has not been treated with metal conditioner and conversion coating or its equivalent.
9. Do not apply lacquer over an unsealed enamel coat.
10. Spray two or three medium coats of primer-surfacer rather than one wet coat.

UNIT III

JOB SHEET #1, LESSON TWO

SELECT AND APPLY APPROPRIATE PRIMER, GUIDE COAT, AND SEALER

Equipment:

Proper primer-surfacer
Proper thinner or reducer
Guide coat of color contrasting primer-surfacer
Final cleaner
Tack rag and paper towels
Paint paddles and strainer
Viscosity cup
Paint gun
Proper sandpaper and sanding block
Scratch putty and rubber squeegee, if needed
Blow gun attachment
Eye protection
Recommended respirator
Masked vehicle

Procedure:

	Evaluation: 3	2	1	N
1. Perform appropriate sand and masking operations.	___	___	___	___
2. Put on eye protection and respirator.	___	___	___	___
3. Select and mix primer-surfacer to recommended percentage, following all label instructions and cautions, then strain mixed primer-surfacer into spray gun cup.	___	___	___	___
4. Adjust spray gun to correct pattern, and adjust pressure at gun to that recommended by primer-surfacer manufacturer.	___	___	___	___
5. Using alternate right and left strokes, and triggering gun at beginning and end of each stroke, apply recommended number of coats, allowing each coat to flash off for recommended length of time.	___	___	___	___
6. Allow primer-surfacer to dry for length of time recommended by manufacturer, then sand and clean thoroughly.	___	___	___	___
7. Mix guide coat and spray light guide coat over entire panel, then lightly sand repair area with recommended sandpaper.	___	___	___	___

Procedure:	**Evaluation:** 3	2	1	N
8. Blow clean with compressed air and wipe with tack cloth then re-prime and apply guidecoat again, if necessary.	___	___	___	___
9. If needed, apply scratch putty to any minor scratches or chips in surface, allow recommended drying time, then block-sand with recommended paper.	___	___	___	___
10. Use blow gun to remove dirt from surface and cracks, and wipe sanded area with tack cloth, then wash area with final cleaner and re-prime, if needed.	___	___	___	___
11. Select and mix appropriate sealer according to manufacturer's instructions.	___	___	___	___
12. Strain mixture into paint cup and set spray gun air pressure at gun to sealer manufacturer's recommendation.	___	___	___	___
13. Apply an even, medium coat of sealer.	___	___	___	___
14. Allow sealer to dry according to sealer manufacturer's recommendations.	___	___	___	___
15. Wipe sealed area with tack rag and apply topcoat as soon as possible following proper job sheet in Unit IV.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competencies M7 "Select and apply appropriate primer/primer surfacer/sealant"and M8 "Perform guide coat/block sanding/reprime.")

MODULE: PAINT AND REFINISHING

UNIT III: SURFACE PREPARATION

UNIT III TEST

I. Match the term in right column with the corresponding definition in the left column

_____1. Sanding beyond the featheredge

_____2. Abrasive coating on sandpaper

_____3. Overlap of dry spray gun particles

_____4. Marks left by sanding operations

_____5. Using very fine sandpaper to sand painted surfaces lightly

_____6. Ability of one substance to stick to a different substance

_____7. Initial stage of paint drying

_____8. The degree to which a paint obscures what is underneath

_____9. The ability of a surface to keep topcoat from bleeding

_____10. Undercoating material used to promote adhesion and prevent corrosion

_____11. Undercoating material used to prevent bleed-through

_____12. Undercoating material used to fill scratches, promote adhesion and prevent corrosion

_____13. Thick primer used to fill minor imperfections

_____14. Layers of paint material used to provide a proper surface for color coats

A. Holdout

B. Hiding

C. Adhesion

D. Back-sanding

E. Overspray

AB. Primer

AC. Scratch putty

AD. Primer-sealer

AE. Undercoat

BC. Bleeding

BD. Flash off

BE. Sand-scratch swelling

CD. Grit

CE. Scuff-sanding

DE. Primer-surfacer

II. Select the best answer from the choices listed.

_____15. A sanding block is used to: (a) prevent sand scratches, (b) prevent uneven sanding, (c) prevent the sandpaper from clogging, (d) prevent poor adhesion, (e) all of the above.

_____16. Chemical stripping is a procedure that is NOT recommended for: (a) panel refinishing, (b) complete refinishing, (c) badly weathered or cracked finishes, (d) modern vehicles, (e) spot repair.

_____17. Which of the following is NOT a reason for sanding: (a) to repair damaged metal, (b) to remove paint, (c) to provide adhesion, (d) to provide smooth surface, (e) to remove foreign particles.

_____18. In areas to be repainted where the old finish is in good condition, which type of sanding would you do? (a) thorough sanding, (b) scuff sanding, (c) featheredging, (d) bare metal sanding, (e) grind sanding.

_____19. In areas to be repainted where portions of the old finish have been removed to the bare metal, which type of sanding would you do? (a) thorough sanding, (b) scuff sanding, (c) featheredging, (d) bare metal sanding, (e) grind sanding.

_____20. The type of primer which requires double-masking procedures is (a) primer-sealer, (b) epoxy primer, (c) lacquer primer, (d) enamel primer, (e) urethane primer.

_____21. Which of the following is NOT a quality of a good primer-surfacer: (a) provides corrosion protection, (b) fills small scratches, (c) promotes adhesion, (d) fast drying, (e) prevents bleed-through.

_____22. Which of the following undercoats must be sanded? (a) sealer, (b) conversion coating, (c) primer-surfacer (d)primer-sealers, (e) c and d.

_____23. A sealer is recommended in which of the following cases: (a) enamel over lacquer, (b) lacquer over enamel, (c) enamel over enamel, (d) light coat over dark coat, (e) all of the above.

III. Mark a T on the answer sheet if the statement is true and an F if the statement is false.

_____24. Wet sanding is faster than dry sanding.

_____25. Wet sanding prevents the sandpaper from clogging.

_____26. Wet sanding leaves behind residue that could cause scratches.

_____27. You should perform final sanding operations in the spray booth.

_____28. You should sand in an orbital pattern, trying to imitate the motion of an orbital sander.

_____29. Metal conditioners remove wax and grease.

_____30. Metal conditioners should be used on all bare metal.

_____31. Conversion coatings inhibit rust and corrosion.

_____32. Conversion coatings are used when a metal conditioner is not used.

_____33. When using masking paper on large areas, the bottom sheet should overlap the top sheet.

_____34. Before taping weatherstripping, you should apply a thin layer of clear lacquer.

_____35. Masking tape and paper should be left on the vehicle until the paint is dry to the touch.

_____36. If the a featheredge breaks it is a sign that you must stop sanding.

_____37. You should spray one wet coat of primer-surfacer.

_____38. You should frequently check sanding progress by rubbing your fingers over the sanded area.

IV. For answers 39-44 on the answer sheet, order the steps given for vehicle refinishing below into their correct sequence of being done. Place the letter of the first step as the answer for question 45, the letter of the second step as the answer for question 46, etc. *(NOTE: Each of the answers will be used only once).*

_____39. A. Wash and dry vehicle
_____40. B. Treat bare metal
_____41. C. Apply plastic filler and smooth
_____42. D. Mask vehicle
_____43. E. Make panel and frame repairs
_____44. AB. Wipe dust and blow dust from crevices

V. For answers 45-50 on the answer sheet, order the steps given for vehicle refinishing below into their correct sequence of being done. Place the letter of the first step as the answer for question 39, the letter of the second step as the answer for question 40, etc. *(NOTE: Each of the answers will be used only once).*

_____45. A. Spray on and sand primer-surfacer
_____46. B. Wash and re-mask, if needed
_____47. C. Spray on color coat
_____48. D. Spray on sealer
_____49. E. Apply scratch putty and re-prime and re-sand, if needed
_____50. AB. Spray on and sand guide coat

(NOTE: Completion of this unit test is the evaluation for Competency M1 "Identify surface preparation technique." Of the 50 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____correct or below, student should retake this test.)

ANSWERS TO UNIT III TEST

1. D
2. CD
3. E
4. BE
5. CE
6. C
7. BD
8. B
9. A
10. AB
11. AD
12. DE
13. AC
14. AE

15. B
16. E
17. A
18. B
19. C
20. E
21. E
22. C
23. E

24. F
25. T
26. F
27. F
28. F
29. F
30. T
31. T
32. F
33. F
34. T
35. F
36. F
37. F
38. F

39. E
40. C
41. AB
42. A
43. D
44. B

45. A
46. AB
47. E
48. B
49. D
50. C

MODULE: PAINT AND REFINISHING

UNIT IV: TOPCOATS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify types of topcoats and apply various topcoats to vehicles. This knowledge will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Match terms with their definitions or illustrations (Competency M9, Unit IV test)

II. Identify modern vehicle finishes (Competency M9, Unit IV test)

III. Identify topcoat selecting and mixing procedures (Competency M9, Unit IV test)

IV. Demonstrate the ability to:

  a. Mix topcoat (Competencies M10-M13, Job Sheet #1)

Lesson 2:

I. Match terms with their definitions (Competency M9, Unit IV test)

II. Identify topcoat application techniques (Competency M9, Unit IV test)

III. Identity paint problems and their causes (Competency M9, Unit IV test)

IV. Identify procedures for preventing dirt in topcoat (Competency M9, Unit IV test)

V. Identify color sanding procedure (Competency M9, Unit IV test)

VI. Demonstrate the ability to:

  a. Apply acrylic lacquer (Competency M10, Job Sheet #1)

  b. Apply alkyd enamel (No competency, Job Sheet #2)

  c. Apply acrylic enamel (Competency M11, Job Sheet #3

  d. Apply urethane enamel (Competency M12, Job Sheet #4)

  e. Apply two-stage system (Competency M13, Job Sheet #5)

Lesson 3:

I. Identify 3-stage systems and application techniques (Competency M13, Unit IV test)

II. Demonstrate the ability to:

  a. Apply three-stage system (Competency M13, Job Sheet #1)

MODULE: PAINT AND REFINISHING

UNIT IV: TOPCOATS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

  1. Lesson 1: Topcoat Composition and Mixing

    a. Information outline

    b. Job sheets

    JS#1: Mix topcoat

  2. Lesson 2: Topcoat Applications

    a. Information outline

    b. Job Sheets

    JS#1: Apply acrylic lacquer
    JS#2: Apply Alkyd enamel
    JS#3: Apply acrylic enamel
    JS#4: Apply urethane enamel
    JS#5: Apply two-stage system

  3. Lesson 3: Three-Stage Systems

    a. Information outline

    b. Job Sheets

    JS#1: Apply three-stage system

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. On Job Sheet #2, Lesson Two, there is no competency for alkyd enamel. If this job sheet is used, it would evaluate a new competency, which could be added to the student's profile.

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MODULE: PAINT AND REFINISHING

UNIT IV: TOPCOATS

LESSON ONE: MIXING AND APPLYING TOPCOATS

I. **Terms and definitions**

A. Clearcoat -- A paint containing no pigment applied over colorcoat to provide gloss and durability.

B. Curing -- The chemical reaction that takes place in paints that dry by chemical reaction.

C. Drier -- A catalyst added to paint that speeds drying or curing time.

D. Factory package -- Paint which has been mixed and sealed by paint manufacturer.

E. Flow-out -- The leveling characteristics of newly applied paint.

F. Metallic paint -- Paint containing small particles of ground-up material, usually aluminum powder.

G. OEM -- The paint supplied by the Original Equipment Manufacturer (OEM).

H. Oxidation -- For painting, the process of oxygen combining with the paint film.

I. Paint film -- The actual thickness of the paint on a surface, measured in mils (thousandths of an inch). The average OEM paint job is 2.5 mils thick.

J. Retarder -- A solvent added to paint that reduces the evaporation time of the volatiles.

K. Shrinkage -- Act of paint shrinking as it dries, which can reveal scratches and other surface imperfections that have not been properly filled.

M. Topcoat -- Final layers of paint applied, including the color coat and clear coat (if used).

N. Two-stage system -- Topcoat application including a color base coat followed by a clearcoat.

II. **Modern vehicle finishes**

A. The three basic ingredients in all paints

1. Volatiles (FIG. 1-1)

a. The portion of the fluid which evaporates

b. Main function is to make paint thin enough for spray application

c. Are either thinners or reducers

675

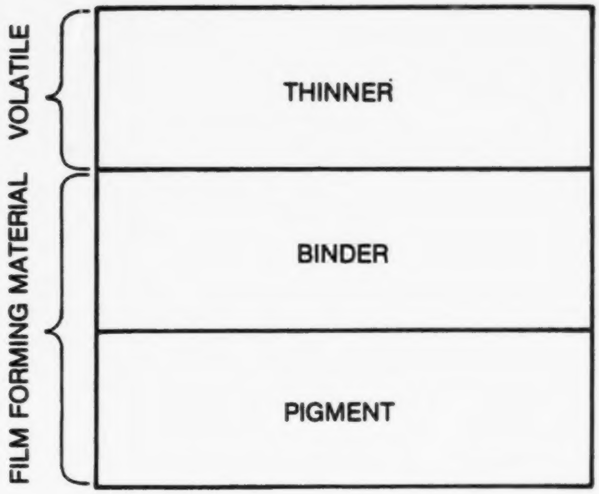
d. Come in different types, characterized by how fast they evaporate and how much they thin the film-forming materials

2. Film-forming materials (FIG. 1-1)

a. Pigment – Coloring portion which produces the ability to hide what is underneath and also acts as a protection to the binder.

b. Binder – Ingredient that acts as a carrying medium of the pigment and gives adhesion, build, toughness and gloss to the film.

FIGURE 1-1



3. Additives

a. Present in many paints

b. May speed drying (driers) or slow drying (retarders)

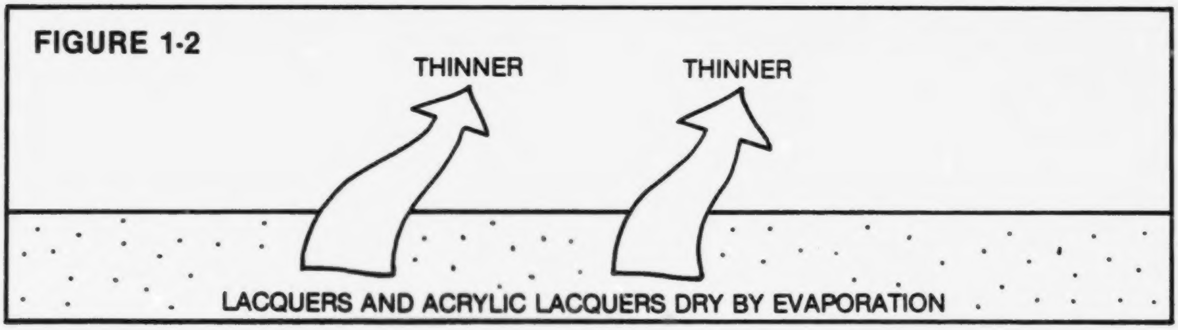
c. May be added to prevent paint problems such as wrinkling, fisheyes, etc.

B. Types of modern vehicles topcoat and topcoat systems

(NOTE: All paints are either lacquers or enamels.)

1. Lacquer and acrylic lacquer (FIG. 1-2)

FIGURE 1-2


THINNER
THINNER
LACQUERS AND ACRYLIC LACQUERS DRY BY EVAPORATION

   a. Dry by evaporation of the volatiles

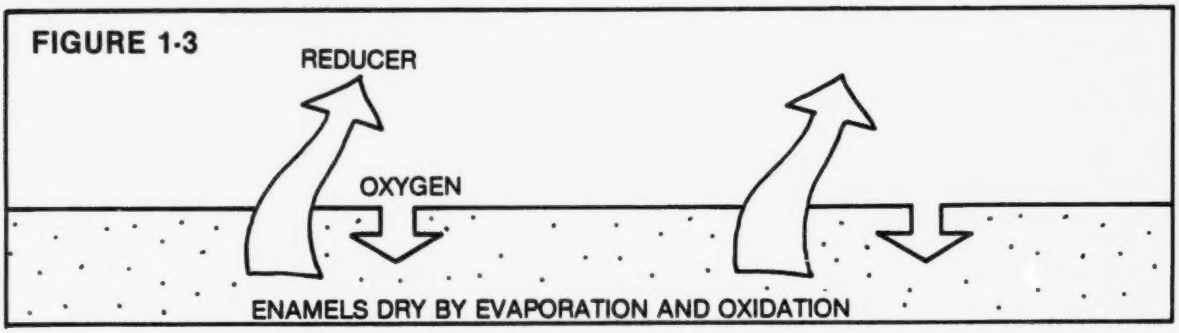
   b. Volatiles are called thinners

   c. Paint remains soluble

   d. Acrylic lacquer is still used as OEM finish by General Motors and is often used for spot repairs on both lacquer and enamel finishes

2. Alkyd enamel and acrylic enamel (FIG. 1-3)

FIGURE 1-3


REDUCER
OXYGEN
ENAMELS DRY BY EVAPORATION AND OXIDATION

   a. Dries by evaporation of the volatiles in first stage or drying and by oxidation of the binder in the second stage.

   b. Volatiles are called reducers

   c. Heat application speeds drying

   d. Paint becomes insoluble in ordinary solvents after thoroughly dry - therefore a thorough sanding is required for repainting

   e. Takes up to one month for complete drying

   f. Acrylic enamel is presently used by American Motors Corporation, Chrysler, and Ford Motor Company as finishes on many of their automobiles.

   g. Recommended for panel repairs and overall painting

3. Polyurethane enamel

   a. Dries by evaporation of the volatiles and by chemical reaction between the two principal base components (hydroxyls and polyisocyanates)

   b. Rapidly becomes resistant to many elements that would damage other type paints

   c. Isocyanates are toxic and good ventilation with an approved respirator is essential when spraying

   d. Polyurethanes are mixed using an activator as well as a reducer and the paint hardens so quickly that the gun must be thoroughly cleaned immediately after use

4. Acrylic urethanes

   a. Similar to polyurethane enamels

   b. Acrylic base gives paint a metallic color capability

5. Water-based acrylic enamel

   a. Used in some factory applications

   b. Purpose is the meet federal emission standards in factory painting operations

   c. Is equally as durable as any acrylic enamel

   d. Finish must be sanded and a sealer applied before the repair paint is sprayed on. (A spot repair cannot be made on water-based enamel.)

6. Clearcoats

   a. May be either acrylic lacquers, acrylic urethane enamels or urethane enamels

   b. Used in two-stage (basecoat-clearcoat) paint applications

   c. After highly-pigmented enamel or lacquer color coat is applied, clearcoat of same type is applied to increase luster and durability

   d. Used on selected basis by most auto manufacturers

   e. Must be repaired using basecoat-clearcoat technique

7. Vinyl paints

   a. Dry by evaporation of volatiles

   b. Dry rapidly to a permanent flexible film

   c. Used to refinish or repair vinyl parts

8. Flexible paints

    a. Formed by adding flexible additives to various color coat systems.

    b. Allow paint to flex so that flexible parts can be coated

9. Chip-resistant coatings

    a. Vinyl-like paints applied to lower portion of body panels on some vehicles

    b. Purpose is to guard against chips from road hazards

    c. Must be replaced after undercoat is sprayed and before topcoat is applied

10. Trunk paint

    a. Designed to give pleasing appearance to truck interiors without needing to prepare surface carefully

    b. Provides a thick, rough coating with a speckled appearance, due to presence of a second color pigment

C. Comparison of acrylic lacquer and acrylic enamel paints

(NOTE: Acrylic is a plastic-like polymer added to paint which improves durability, gloss and color retention. Most body shop applications today are acrylic lacquer or acrylic enamel.)

1. Acrylic lacquer paint

    a. Uses thinner as vehicle

    b. Fast-drying

    c. Requires several coats

    d. Needs polishing to bring out high gloss

    e. Will not hide small imperfections as well as enamel

2. Acrylic enamel paint

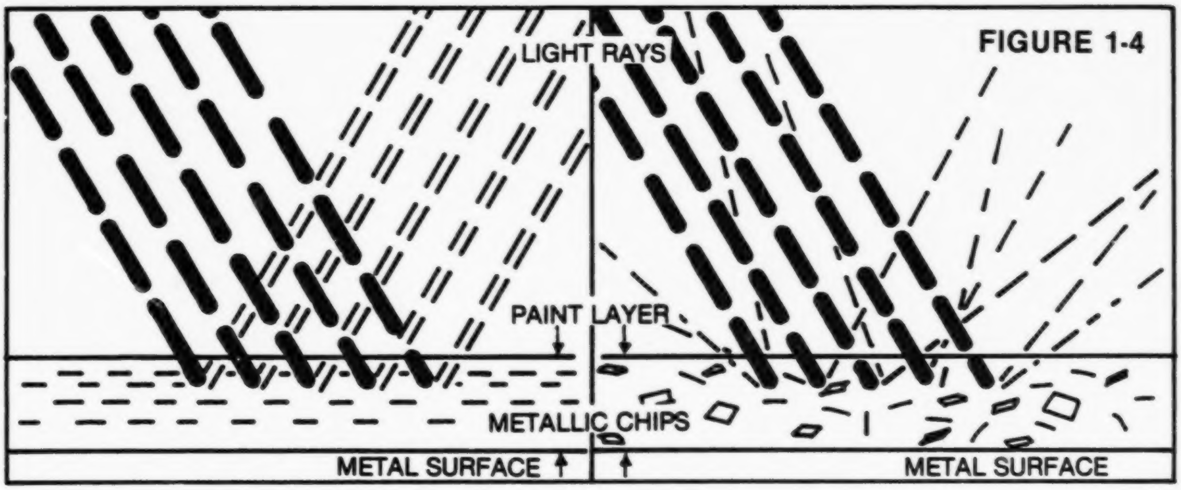
    a. Uses reducer as vehicle

    b. Dries slower than acrylic lacquers

    c. Requires fewer coats, but is more sensitive to spraying techniques and settings

    d. Flows out well to hide small imperfections

D. Metallic paint (FIG. 1-4)



1. Metallic chips, usually aluminum, are in paint
2. Chips reflect light giving metallic sheen to finish
3. Chips fall at different angles, giving iridescent appearance
4. Spraying metallic paint requires great skill
5. Repairing metallic paint is difficult because the angle of the chips changes the appearance of the paint

E. Two-stage systems (basecoat-clearcoat)

1. May be either lacquer or enamel
2. Uses
   a. Provide extra-high-gloss to color coat

      (Many two-stage systems use a highly-pigmented but low-gloss basecoat.)

   b. Protective coats over custom work
   c. Prevents buffing through on spot repairs
   d. Prevents weathering on blended edge of spot repair
3. Tips on clearcoat application
   a. Don't use too much clear - it will bury the topcoat
   b. Don't spray too thick - thin according to manufacturer's recommendations
   c. Use only recommended thinners and reducers

        d. Many applications require a special adhesion promoter to be sprayed prior to the basecoat application

    4. Surface preparation

        a. After priming, wet-sand area for basecoat application with 400-grit or finer sandpaper.

        b. Wet-sand area for clear blending coat with 600 or finer sandpaper.

        c. Apply adhesion promoter

        d. For spot repair and blending techniques, consult Unit V, Lesson 1

III. Selecting and mixing topcoats

A. Topcoat selection

1. If performing complete paint job, topcoat selection is unlimited provided surface is properly prepared

2. If performing a panel or spot repair, select OEM paint by referring to paint code on vehicle identification tags

3. Always check to be sure that vehicle has not been repainted, no longer having OEM finish

4. Always check condition and type of old paint in order to determine types of undercoats and topcoats required

5. Follow paint manufacturer's guidelines

6. After mixing paint for a spot repair, always be sure of proper color match by spraying some on a test panel and allowing to dry

B. Using vehicle paint I.D. tags

1. Possible locations of I.D. tags

(NOTE: Estimating guides will give exact locations for each vehicle.)

a. Top or front of cowl panel

b. Glove box door or left inner fender

c. Left inside door frame

d. Left fender apron or radiator support

e. Left hinge pillar post

f. Behind or under spare tire

g. On firewall

(NOTE: Some manufacturers are now using multiple tags showing the location and identification of different types of paints, as in the case of a vehicle with metal panels, plastic panels, rubber panels, etc.)

C. Procedure for using I.D. tag

1. Check I.D. tag on vehicle
2. Match I.D. number or letter with color chip in color chip book
3. Compare color chip with color of vehicle

D. Mixing topcoats

1. Be sure to stir paint thoroughly, reaching into corners of paint can, or use a paint shaker, if available
2. Be sure to follow paint manufacturer's recommendations for reducer/thinner type and reduction amounts
3. Do not allow paint to settle after mixing
4. Check paint viscosity to make sure proper thinning/reducing has been achieved
5. Remember that shop temperatures can change paint viscosity. Follow temperature compensation instructions on paint can.

UNIT IV

JOB SHEET #1, LESSON ONE

MIX TOPCOAT

Equipment:

Appropriate paint
Paint gun
Paint paddle and strainer
Reducer or thinner
Eye protection
Proper respirator
Tack rag
Prepared test panel

Procedure:

Evaluation:
3 2 1 N

1. Check paint code on body identification plate to determine paint needed. ____ ____ ____ ____

2. If vehicle has been repainted and does not have original factory paint, make the following test to determine paint type. ____ ____ ____ ____

    a. Apply small amount of lacquer thinner to clean, white rag.

    b. Rub dampened rag on paint on fender lip or in other out-of-sight location near bottom of body.

    c. Examine rag: If paint colors rag, the paint is lacquer-type; if thinner curdles paint, causing it to lift and bubble, the paint is enamel-type.

3. Mix a small amount of paint according to manufacturer's instructions. ____ ____ ____ ____

4. Check paint viscosity by checking paint dripping time in viscosity cup. Adjust viscosity if needed. ____ ____ ____ ____

5. Put small amount of mixed paint into spray gun, spray on properly prepared test panel. ____ ____ ____ ____

6. Check test panel match against vehicle. If match is achieved, mix rest of paint. ____ ____ ____ ____

Average of above evaluations* ____ ____ ____ ____

(*This average will become part of the job sheets in Lesson Two.)

MODULE: PAINT AND REFINISHING

UNIT IV: TOPCOATS

LESSONS TWO: TOPCOAT APPLICATION

I. **Terms and definitions**

A. Banding coat -- An application of paint framing the edges of a surface to be painted to ensure even coverage in crevices and indentations.

B. Color sand -- Using very fine sandpaper to lightly sand a newly painted lacquer surface to bring out gloss.

C. Compounding -- The action of using an abrasive material to give a painted surface a gloss.

D. Cross hatch coat -- Checkerboard application to assure a continuous film when spraying transparent or clean finishes. Consists of one medium coat in one direction followed by a second medium coat perpendicular to the first.

E. Double coat -- Spraying first pass left to right and then second pass right to left directly over first pattern.

F. Dry spray -- Paint that does not dissolve into the material being sprayed, usually caused by too fast of reducer or thinner, holding gun too far from the surface or too high of air pressure.

G. Fog coat -- A fully reduced or thinned paint that is applied at higher than normal air pressure, or the gun held at a great distance from the surface.

H. Mist coat -- Over-thinning the color or using straight reducer or thinner. Used to blend in final lap areas and also as a means of pre-wetting a surface before applying spot repair color lacquers.

I. Mottling -- A paint defect that appears as blotches or surface imperfections. Often associated with metallic paint.

J. Orange peel -- A nubby surface looking like the skin of an orange, caused by poor flow due to too fast a reducer or lack of atomization.

K. Pitch -- Angle of the reflecting flakes in metallic paint after it sets up.

L. Single coat -- Spray first pass left to right, drop nozzle to 50% of spray pattern, overlapping bottom half of original pass, returning right to left.

M. Tack coat -- the first coat with enamel, a full coat that is allowed to dry until quite sticky.

II. **Coat application techniques**

A. Types of coats

1. Banding coat - Applying single color coat in a small spray pattern to frame the edges of an area to be painted
    a. Paint is sometimes thinned more than rest of coats
    b. Done to insure coverage of indentations and crevices on edges
2. Mist coat - Spraying rich, slow-drying thinner or reducer with little or no color added
    a. Used to level final coat and to melt in overspray
    b. Used in tinting and blending a spot repair (See Unit 5, Lesson 1)
3. Single coat - Spraying coat so that each pass overlaps the previous one by 50% (FIG. 2-1)
    a. Usual technique for enamel, with two single coats applied, the first called the tack coat
4. Double coat - Spraying two passes before dropping down for a 50% overlap on the next double pass
    a. Usual technique for lacquer applications with two or more double coats applied

B. Coat thickness applications
1. Fog coat - Very light spray of a fully reduced coat
    a. Gun moved very fast and/or held very far from surface
2. Dry - Light coat which does not flow out and remains dull
    a. Gun moved fast and/or held farther than recommended from surface
3. Medium - Average coat
    a. Gun moved at standard speed and held at correct distance
4. Wet - Heavy coat
    a. Gun moved slower than normal and held at correct distance

III. **Troubleshooting application problems**

A. Bleeding - old finish bleeding through to surface of new paint
1. Caused by improper sealing
2. Requires removal of all color coats or allowing surface to cure, sealing, and re-coating

B. Blistering - small swelled areas

1. Caused by rust on surface, oil or grease, moisture in spray lines, trapped solvent or high humidity

2. Requires sanding and refinishing blistered areas

C. Blushing - finish turning milky on acrylics and lacquer

   1. Cause by fast thinners in high humidity, unbalanced thinners or condensation on old surface

   2. Requires adding retarder to thinner and re-spraying or in some cases sanding and refinishing

D. Chalking - lack of gloss or powdery surface

   1. Caused by lack of thorough stirring of paint or using wrong thinner

   2. Requires sanding, cleaning and refinishing

E. Checking, crazing or cracking - irregular depressions in paint

   1. Caused by any of the following

      a. Insufficient drying of first coats

      b. Excessive heavy coats

      c. Extreme temperature changes

      d. Not mixing paint thoroughly

      e. Adding improper materials to paint

   2. Requires removing finish down through checked paint and refinishing

F. Dirt in finish - foreign particles in paint

   1. Caused by improper maintenance of equipment work area, or incomplete preparation of vehicle

   2. May be rubbed out if lacquer or sanded and compounded if enamel, but may require sanding and re-coating

G. Dulled finish - gloss leaves as paint dries

   1. Caused by compounding too soon, improper thinner or reducer, poorly cleaned surface, topcoats put on wet undercoats, improper surface cleaning, or bad polishes

   2. May be remedied by allowing finish to thoroughly dry and compounding

H. Fisheyes - separation of the wet film with previous finish showing through fisheyes

   1. Caused by improper surface preparation

2. May be remedied by adding fisheye eliminator, but where fisheyes have already appeared paint must be removed while wet, surface prepared and re-coated

I. Lifting - raising and swelling of wet film

1. Caused by improper drying of previous coat, sandwiching enamel between two lacquers or acrylics, re-coating of improperly cured enamel or spraying over unclean surfaces

2. Requires removing finish and re-coating

J. Mottling - streaking of the color in metallic finishes

1. Caused by uneven film application

2. May be solved by applying another coat properly while first coat is still wet, or may require scuffing and re-coating if dry

K. Orange peel - resembles skin of an orange

1. Caused by improper reduction/thinning or improper air pressure

2. Enamel may be solved by rubbing with mild polishing compound and lacquer by sanding or using rubbing compound. May require sanding and refinishing, however.

L. Peeling - separation of paint film from substrate

1. Caused by improper surface preparation or incompatibility of coats

2. Paint must be removed, surface properly prepared and re-coated

M. Runs - wet paint running in rivulets

1. Caused by over-reduction with low air pressure, too slow of thinner, cold surface or improperly cleaned surface

2. Requires removing paint and refinishing

N. Sags - Slipping of paint-forming curtains or film that is too heavy to support itself

1. Caused by under-reduction, not allowing proper drying time between coats, low air pressure, gun held too close, or gun out of adjustment

2. Requires removing paint and refinishing

O. Undercoat showing through

1. Caused by insufficient color coats or repeated compounding

2. Requires sanding and refinishing

P. Wrinkling - puckering of enamel in prune skin effect

1. Caused by under-reduction or air pressure too low, excessive coats, fast reducers, or fresh film subjected too quickly to heat
2. Requires sanding top surface to break open wrinkles and allowing thorough drying

IV. **Preventing dirt in surface**

A. Clean vehicle thoroughly, including pressure cleaning underside and engine compartment

B. Wet down floor in paint booth before spraying

C. Complete surface preparation outside of paint booth

D. Keep equipment clean

E. Wear clean clothes and disposable coveralls

F. Use clean tack rags

G. Ground vehicle electrically to prevent static electricity from attracting dust

H. Keep paint booth doors closed during paint operation and leave closed for one hour after application

V. **Color sanding**

A. Used in lacquer refinishing and some basecoat-clearcoat systems

B. After paint has cured, surface is dry sanded with 600-sandpaper

C. Only very light sanding is done, followed by buffing to bring out high gloss

UNIT IV

JOB SHEET #1, LESSON TWO

APPLY ACRYLIC LACQUER

Equipment:

Acrylic lacquer paint
Measuring equipment
Strainer
Equipment for testing viscosity
Proper primer
Proper thinners
Vehicle or panel
Wax and grease remover
Water
Masking tape
Sandpaper
Tack rag
Spray gun
Compound
Buffer
Proper safety equipment

Procedure:

Evaluation:
3 2 1 N

1. Prepare surface by performing Job Sheet #1, Lesson 2, Unit III. ___ ___ ___ ___

2. Mix paint by performing Job Sheet #1, Lesson 1, this unit according to paint manufacturer's recommendations and fill pressure pot/siphon cup. ___ ___ ___ ___

   (Lacquer will normally be thinned with 100 to 150 percent thinner.)

3. Adjust spray gun settings according to paint manufacturer's recommendations. (Normally the pressure will be set from 40 to 55 pounds at the gun.) ___ ___ ___ ___

4. Tack entire area to be sprayed. ___ ___ ___ ___

5. Using appropriate technique, spray one full wet coat. ___ ___ ___ ___

6. Allowing proper flash time between coats apply at least two more coats until desired coverage is reached. ___ ___ ___ ___

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
7. Allow at least four hours for air drying, or preferably overnight, then color sand finish.	___	___	___	___
8. After color sand, buff finish.	___	___	___	___
9. Re-buff if needed.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency M10 "Mix and apply acrylic lacquer system.")

UNIT IV

JOB SHEET #2, LESSON TWO

APPLY ALKYD ENAMEL

Equipment:

Synthol (Alkyd) enamel paint
Measuring equipment
Strainer
Equipment for testing viscosity
Proper primer
Proper reducers
Vehicle or panel
Wax and grease remover
Water
Masking tape
Sandpaper
Tack rag
Spray gun
Proper safety equipment

Procedure:

Evaluation:
3 2 1 N

1. Prepare surface by performing Job Sheet #1, Lesson 2, Unit III. ___ ___ ___ ___

2. Mix paint by performing Job Sheet #1, Lesson 1, this unit according to paint manufacturer's recommendations and fill pressure pot/siphon cup. ___ ___ ___ ___

   (Synthol enamel will normally be reduced with 25 to 50 percent reducer, although some applications call for 100 percent reduction.)

3. Adjust spray gun settings according to paint manufacturer's recommendations. ___ ___ ___ ___

   (Normally the pressure will be set from 40 to 45 pounds at the gun.)

4. Tack entire area to be sprayed. ___ ___ ___ ___

   For non-polychromatic colors:

5. Using appropriate technique, spray one full wet coat. ___ ___ ___ ___

   (NOTE: Some applications recommend a light first coat. Follow paint manufacturer's recommendations.)

Procedure: **Evaluation:**

3 2 1 N

6. Allow proper flash time, then spray a second full, wet coat. ___ ___ ___ ___

For polychromatic (metallic) colors:

5. Using appropriate technique, spray one full wet coat. ___ ___ ___ ___

6. Allow proper flash time then spray a second full, wet coat. ___ ___ ___ ___

7. Wait 10 to 15 minutes, then apply fog coat. ___ ___ ___ ___

(NOTE: Some applications call for a third full wet coat instead of a fog coat.)

Average of above evaluations* ___ ___ ___ ___

(*This average may be used as an additional competency, but it is not currently a Missouri competency.*)

UNIT IV

JOB SHEET #3, LESSON TWO

APPLY ACRYLIC ENAMEL

Equipment:

Acrylic enamel paint
Measuring equipment
Strainer
Equipment for testing viscosity
Proper primer
Proper reducers
Vehicle or panel
Wax and grease remover
Water
Masking tape
Sandpaper
Tack rag
Spray gun
Proper safety equipment

Procedure:

Evaluation:
3 2 1 N

1. Prepare surface by performing Job Sheet #1, Lesson 2, Unit III. ___ ___ ___ ___

2. Mix paint by performing Job Sheet #1, Lesson 1, this unit according to paint manufacturer's recommendations and fill pressure pot/siphon cup. ___ ___ ___ ___

   (Acrylic enamel will normally be reduced with 33 to 50 percent reducer)

3. Adjust spray gun settings according to paint manufacturer's recommendations. ___ ___ ___ ___

   (For non-polychromatic paint set pressure at a maximum 50 pounds, with a spray pattern 10-inches high. For polychromatic paint set pressure at a maximum 60 pounds with a spray pattern 10 inches high.)

4. Tack entire area to be sprayed. ___ ___ ___ ___

5. For both polychromatic and non-polychromatic colors, spray one full wet coat using appropriate techniques. ___ ___ ___ ___

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
6. When dry to touch, spray a second full, wet coat.	___	___	___	___
(NOTE: Touch paint on masking tape. Never touch painted surface.)				
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency M11 "Mix and apply acrylic enamel system.")

UNIT IV

JOB SHEET #4, LESSON TWO

APPLY URETHANE ENAMEL

Equipment:

Urethane enamel paint
Proper activator (catalyst)
Measuring equipment
Strainer
Equipment for testing viscosity
Proper primer
Proper reducer
Vehicle or panel
Wax and grease remover
Water
Masking tape
Sandpaper
Tack rag
Spray gun
Proper safety equipment

Procedure:	**Evaluation:** 3	2	1	N
1. Prepare surface by performing Job Sheet #1, Lesson 2, Unit III.	___	___	___	___
2. Mix paint by performing Job Sheet #1, Lesson 1, this unit according to paint manufacturer's recommendations and fill pressure pot/siphon cup.	___	___	___	___
(**CAUTION:** *Urethane paint must not be allowed to sit in the gun. Apply paint immediately and clean gun immediately after finishing job.*)				
3. Adjust spray gun settings according to paint manufacturer's recommendations.	___	___	___	___
4. Tack entire area to be sprayed.	___	___	___	___
5. Spray topcoats according to paint manufacturer's recommendations.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency M12 "Mix and apply urethane enamel system.")

UNIT IV

JOB SHEET #5, LESSON TWO

APPLY TWO-STAGE SYSTEM

Equipment:

Basecoat
Clearcoat
Proper activator/reducer/thinner
Measuring equipment
Strainer
Equipment for testing viscosity
Vehicle or panel
Wax and grease remover
Water
Masking tape
Sandpaper
Final cleaner
Tack rag
Spray gun
Proper safety equipment

(INSTRUCTOR'S NOTE: For the purpose of this evaluation a complete panel, test panel or a complete vehicle should be used, as opposed to a spot repair.)

Procedure: **Evaluation:**
3 2 1 N

1. Prepare surface by performing Job Sheet #1, Lesson 2, Unit III. ___ ___ ___ ___

2. Wet-sand entire area to receive color coat with 400-grit paper or finer. ___ ___ ___ ___

3. Wash with final cleaner and tack. ___ ___ ___ ___

4. Apply adhesion promoter recommended by paint manufacturer and allow to dry for recommended time. ___ ___ ___ ___

5. Mix basecoat by performing Job Sheet #1, Lesson 1, this unit according to paint manufacturer's recommendations and fill pressure pot/siphon cup. ___ ___ ___ ___

6. Allow basecoat to flash for recommended time and mix clearcoat. ___ ___ ___ ___

   (NOTE: Some clearcoats are premixed.)

7. Apply clearcoat following manufacturer's recommendations. ___ ___ ___ ___

Procedure: **Evaluation:**

3 2 1 N

8. Sand or buff clearcoat, if recommended. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average may be used as the evaluation for Competency M13 "Mix and apply basecoat/clearcoat system.")

MODULE: PAINT AND REFINISHING

UNIT IV: TOPCOATS

LESSON THREE: THREE-STAGE SYSTEMS

I. **Three-stage systems (Pearls)**

A. Three-stage systems are a special paint system, first introduced in 1985.

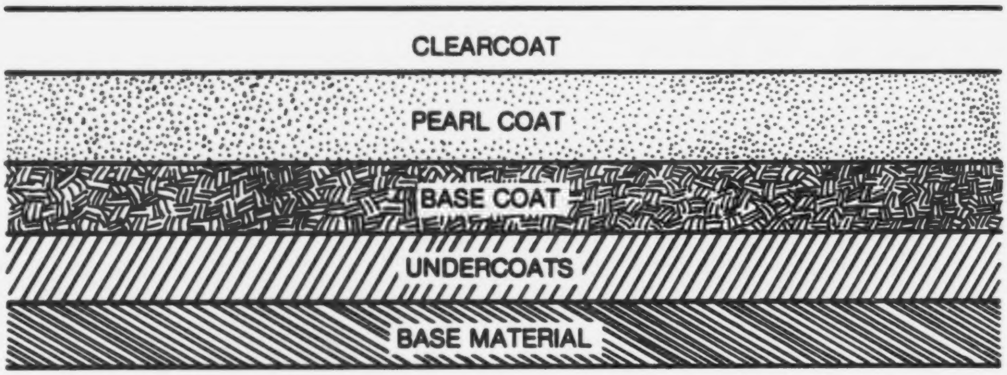
B. Three-stage systems are often called "Pearls" due to an iridescent appearance, similar to that of a pearl.

C. Like two-stage systems, pearls use a basecoat and a clearcoat, with an additional application (the pearl coat) in between.

D. The three stages (FIG 3-1)

1. Basecoat application on prepared surface
2. Pearl coat application
3. Clearcoat application

FIGURE 3-1



E. How the pearl coat works

1. Normal pigments derive their colors from the reflection or absorbtion of light.
2. Pearls produce their colors from light interference
3. An example of light interference is when oil is spilled on water. The rainbow-like iridescence is caused by light reflecting off both the top surface of the oil and the bottom surface of the oil. The two reflections cause an interference and reinforcement of the wavelengths of reflected light.

4. The pearls get their lustre from the application of a microscopic layer of Titanium Dioxide to each side of microscopic platelets of mica.

5. The mica platelets are clear, allowing reflection off both the top and bottom of the platelets.

6. The light reflects at different angles, causing the pearl effect.

F. Special procedures when applying pearls.

1. Pearls are very expensive paints (as much as $75 per quart), so correct mixing and application is extremely important.

2. Because the mica platelets are heavier than the paint, they will settle to the bottom of the paint gun. For that reason, an agitator-type cup is recommended.

3. In applying the basecoat, use check hiding labels to assist in knowing when enough basecoat has been applied. The hiding labels have a black and white checkered pattern and can be placed on an adjacent, masked off area. When the black and white areas are no longer visible, you have applied enough basecoat.

4. An optional procedure is to apply a static reducer to the prepared surface in order to minimizing problems with dust and dirt settling on the paint.

5. An adhesion promoter is required in some applications prior to applying the basecoat.

6. For blending applications, adhesion promoter should be applied 4"-6" onto adjacent panels

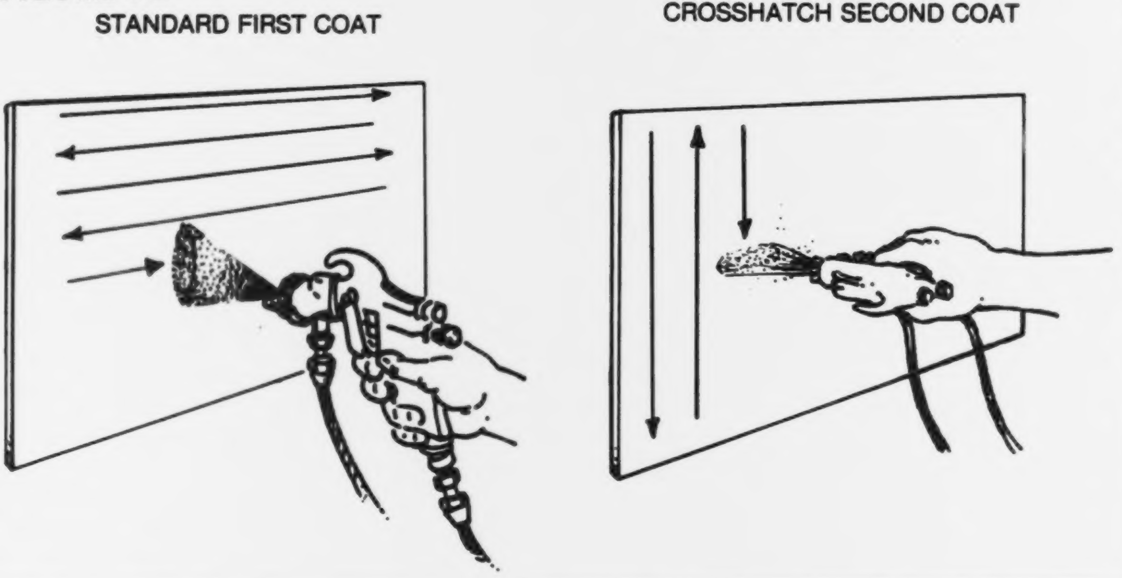
7. For blending applications, do not apply clearcoat beyond area with adhesion promoter.

8. Pearl coat is applied with cross-hatch technique

    a. Apply first coat medium-wet with standard spraying sequence of left to right and right to left, with 50% overlap

    b. Wait 30-60 seconds, then spray medium-wet coat in opposite direction over the previous applied pearl coat, using a vertical application and 50% overlap. (FIG. 3-2, Next page).

FIGURE 3-2


STANDARD FIRST COAT

CROSSHATCH SECOND COAT

9. The pearl coat should be applied with the gun held 10-12 inches from the surface.

10. If making a panel or spot repair, and a match is not achieved, follow this procedure:

    a. If pearl is light compared to panel, then not enough pearl was applied. Repeat application of pearl, using cross-hatch technique

    b. If pearl is too dark, then apply additional base color. After base color is applied, apply additional pearl coat. Repeat process if needed.

G. Clearcoat application

1. Either a lacquer or a polyurethane enamel clearcoat may be recommended

2. If using a polyurethane enamel, you must use an air supply or other approved respirator as this material contains toxic isocyanates.

3. If using a lacquer, then a final pre-mixed mist coat (clear acrylic and solvent) may be used.

4. Apply lacquer clearcoat at 35-45 psi and polyurethane enamel at 50 psi.

5. A lacquer clearcoat should be rubbed out using a light-cutting polishing compound, either for machine or hand application.

6. A polyurethane clearcoat requires rubbing out using a light-cutting machine polishing compound.

UNIT IV

JOB SHEET #1, LESSON THREE

APPLY THREE-STAGE SYSTEM

(NOTE: The following system is a du Pont application. If using another system, be sure to follow any procedures which differ.)

Equipment:

Spray gun with agitator cup
Pearl paint system
Mild soap and water solution
Wax and grease remover
Masking paper/tape
Metal conditioner and conversion coating
Anti-corrosion primer
Primer-surfacer
400-grit wet-or-dry sandpaper
600- or 800-grit wet-or-dry sandpaper
Tack rag
Proper adhesion promoter
Proper polishing compound
Machine polisher (if lacquer clearcoat)
Proper safety equipment

Procedure:	**Evaluation:** **3**	 **2**	 **1**	 **N**
1. Prepare surface by washing with mild soap and water, then wax and grease remover.	___	___	___	___
2. Mask vehicle or adjacent panels.	___	___	___	___
3. Apply metal conditioner and conversion coating.	___	___	___	___
4. Using personal safety equipment, apply primer, following manufacturer's directions.	___	___	___	___
5. Apply primer-surfacer (extending 3-4 inches past repair area if spot repair.)	___	___	___	___
6. Wet sand primer areas with 400-grit (extending 4-6 inches beyond repair area if spot repair.)	___	___	___	___
7. Compound or wet sand with 600- or 800-grit all areas to be painted.	___	___	___	___
8. Reclean all compounded areas, repeating step 1, then tack all prepared areas.	___	___	___	___

Procedure: **Evaluation:**
3 2 1 N

9. Apply anti-static material, if desired, then apply adhesion promoter over all prepared areas, following manufacturer's recommendations. ___ ___ ___ ___

10. With 35-45 psi, apply two or more medium-wet coats of base color, allowing 10-15 minutes flash time between coats. After applying coats for a full hiding, allow base coat to dry 30 minutes. If base color must be sanded, allow basecoat to dry completely. Sand with 600- or 800-grit, reclean and tack, then apply one more coat of base color and allow to dry 30 minutes. ___ ___ ___ ___

11. Apply medium-wet first pearl coat with cross-hatch technique. ___ ___ ___ ___

    a. Set gun for 55-60 psi.

    b. Apply first coat to each area with standard left-right, right-left procedure.

    c. Wait 30-60 seconds and apply second medium-wet cross-hatch coat.

    (NOTE: You must maintain a 10-12-inch distance from the panel and keep the gun stroke steady and very deliberate. The spray fan should be 8-10 inches high.)

12. Allow to air dry 30 minutes if using polyurethane clearcoat, or 1 hour if using a lacquer clearcoat. ___ ___ ___ ___

    (NOTE: If color does not match, follow procedures outlined earlier in this unit.)

13. Apply three or more medium-wet clearcoats at 35-45 psi for lacquer and 50 psi for Polyurethane. ___ ___ ___ ___

    (NOTE: polyurethane enamel has a pot life or eight hours or less and should be applied immediately. The gun must also be cleaned immediately after use.)

14. Apply additional coat (Polyurethane) or mist coat (lacquer), if needed. ___ ___ ___ ___

Procedure: **Evaluation:**
3 2 1 N

15. Allow to dry overnight, or longer, then hand or machine rub with light cutting compound (if lacquer), or machine rub with light cutting compound (if polyurethane). ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average may be used as the evaluation for Competency M13 "Mix and apply basecoat-clearcoat system.")

MODULE: PAINT AND REFINISHING

UNIT IV: TOPCOATS

UNIT IV TEST

I. Match the terms in the right column with their correct definitions in the left column

_____1. Paint containing no pigment

_____2. Catalyst added to speed curing

_____3. Leveling characteristics of paint

_____4. Paint containing aluminum powder

_____5. Solvent added to slow drying time

_____6. Basecoat-clearcoat

_____7. Framing edges of surface to be painted

_____8. Using abrasive to bring out gloss

_____9. Caused by poor flow

_____10. Angle of reflecting flakes

_____11. First coat with enamel

_____12. Spray technique for transparent paint

A. Mist coat

B. Crosshatch coat

C. Orange peel

D. Clearcoat

E. Two-stage system

AB. Metallic paint

AC. Flow-out

AD. Drier

AE. Retarder

BC. Pitch

BD. Banding coat

BE. Compounding

CD. Tack coat

II. Select the best answer from the choices listed.

_____13. The function of volatiles in paint is to: (a) make paint stick, (b) give paint gloss, (c) thin paint, (d) give paint color, (e) evaporate paint.

_____14. The function of pigments in paint is to: (a) make paint stick, (b) give paint gloss, (c) thin paint, (d) give paint color, (e) evaporate paint.

_____15. The function of binders in paint is to: (a) make paint stick, (b) give paint gloss, (c) thin paint, (d) give paint color, (e) evaporate paint.

_____16. Lacquer paint dries by: (a) chemical reaction, (b) evaporation of volatiles, (c) oxidation of binder, (d) a and b, (e) b and c.

_____17. Enamel paint dries by: (a) chemical reaction, (b) evaporation of volatiles, (c) oxidation of binder, (d) a and b, (e) b and c.

_____18. Polyurethane enamel paint dries by: (a) chemical reaction, (b) evaporation of volatiles, (c) oxidation of binder, (d) a and b, (e) b and c.

_____19. Which of the following is a characteristic of lacquer: (a) takes up to one month to dry, (b) hardens very quickly, (c) paint remains soluble, (d) cannot be spot-repaired, (e) both c and d.

_____20. Which of the following is a characteristic of enamel: (a) takes up to one month to dry, (b) hardens very quickly, (c) paint remains soluble, (d) cannot be spot-repaired, (e) both c and d.

_____21. Which of the following is a characteristic of polyurethane enamel: (a) takes up to one month to dry, (b) hardens very quickly, (c) paint remains soluble, (d) cannot be spot-repaired, (e) both c and d.

_____22. Which of the following is a characteristic of water-based acrylic enamel: (a) takes up to one month to dry, (b) hardens very quickly, (c) paint remains soluble, (d) cannot be spot-repaired, (e) both c and d.

III. Mark a T on the test or answer sheet if the statement is true and an F if the statement is false.

_____23. Acrylic lacquer requires several coats.

_____24. Acrylic lacquer needs no polishing.

_____25. Acrylic enamel hides small imperfections.

_____26. Acrylic enamel is easier to spray than most paints.

_____27. In metallic paint, the angle of the chips changes the flow-out of the paint.

_____28. A clearcoat should be applied as thickly as possible without running or sagging.

_____29. Adhesion promoter is necessary when applying a two-stage system.

_____30. You can always tell the type of paint on a vehicle by looking at the paint ID tags.

_____31. If performing a complete paint job, you must apply the same type of paint as was previously applied.

_____32. After mixing paint thoroughly it will not settle out.

_____33. The viscosity of the paint can change according to the temperature.

_____34. Bleeding refers to the primer mixing with the topcoat.

_____35. If properly sealed, corrosion will not cause paint problems.

_____36. A fisheye refers to an area where the old topcoat shows through a separation in the new paint film.

_____37. Runs can be caused by underreduction of the paint.

_____38. Sags can be caused by holding the gun too close to the surface being painted.

_____39. Three-stage systems provide their iridescent appearance due to light interference.

_____40. Pearls are very expensive paints.

_____41. Pearls contain microscopic platelets of aluminum.

_____42. In applying a basecoat, check hiding labels will tell you when you have applied enough paint.

_____43. You must be careful to never use an adhesion promoter prior to applying a basecoat.

_____44. In using the cross-hatch technique, the second coat is sprayed at a right angle to the first coat.

_____45. A pearl coat should be applied with the gun held 8-10 inches from the surface.

(NOTE: Completion of this unit test is the evaluation for Competency M9 "Identify topcoats and topcoat application procedures." Of the 45 questions, a score of _____ correct = 3, _____ = 2, _____ = 1, _____ correct or below, student should retake this test.)

ANSWERS TO UNIT IV TEST

1. D
2. AD
3. AC
4. AB
5. AE
6. E
7. BD
8. BE
9. C
10. BC
11. CD
12. B

13. C
14. D
15. A
16. B
17. E
18. D
19. C
20. A
21. B
22. D

23. T
24. F
25. T
26. F
27. F
28. F
29. T
30. F
31. F
32. F
33. T
34. F
35. F
36. T
37. F
38. T

39. T
40. T
41. F
42. T
43. F
44. T
45. F

MODULE: PAINT AND REFINISHING

UNIT V: COLOR MATCHING AND SPECIAL PAINT APPLICATIONS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify the procedures for and perform a tint and blend on a panel and identify and perform special paint applications. Mastery will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Match terms with their definitions (Competency M14, Part I of Unit V test)

II. Identify principles of color matching (Competency M14, Part I of Unit V test)

III. Identify principles of blending (Competency M14, Part I of Unit V test)

IV. Identify principles of tinting (Competency M14, Part I of Unit V test)

V. Identify principles of changing cast (Competency M14, Part I of Unit V test)

VI. Demonstrate the ability to:

   a. Tint and blend a color coat (Competency M14, Job Sheet #1)

Lesson 2:

I. Match terms with their definitions (Competencies M15, M16, Part II of Unit V test)

II. Identify special paints and paint products (Competencies M15, M16, Part II of Unit V test)

III. Demonstrate the ability to:

   a. Apply chip-resistant coating (Competency M15, Job Sheet #1)

   b. Mix and apply flexible paint system (Competency M16, Job Sheet #2)

   c. Mask and paint stripes (Competency M3, Job Sheet #3)

   d. Retexture plastic dash panel (Competency H7, Job Sheet #4)

MODULE: PAINT AND REFINISHING

UNIT V: COLOR MATCHING AND SPECIAL PAINT APPLICATIONS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

1. Lesson 1: Color Matching

   a. Information outline

   b. Job sheets

   JS#1: Tint and blend color coat

2. Lesson 2: Special Paints and Paint Products

   a. Information outline

   b. Job Sheets

   JS#1: Apply chip-resistant coating
   JS#2: Mix and apply flexible paint system
   JS#3: Mask and paint stripes
   JS#4: Re-texture plastic dash panel

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Job Sheet #4 is the same as Job Sheet #6 in Unit IV (Plastic Repair) of Module 3.

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2. du Pont, E.I. *Auto Refinishing Handbook*. E.I. du Pont de Nemours & Co. Wilmington, DE. 1985.

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5. The Martin-Senour Company. "Methods for Obtaining a Good Color Match." Profinisher, Vol. 10, No. 3, 1987. The Martin-Senour Company. Countryside, IL 1984.

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MODULE: PAINT AND REFINISHING

UNIT V: COLOR MATCHING AND SPECIAL PAINT APPLICATIONS

LESSON ONE: TINT AND BLEND COLOR COAT

I. **Definitions**

A. Blend – Using special application techniques and paint-thinning procedures to camouflage slightly mismatched paint in such a way that it is cannot be detected.

B. Cast – The dominant pigments of a color.

C. Cleanliness – The brightness or grayness of a color.

D. Color shift – A change in the appearance of paint which can result from different application techniques and conditions, despite the application of identical paint.

E. Depth – The lightness or darkness of a color.

F. Tint – Adding pure colors to a mixed paint to change the depth, cast and/or grayness of the paint in order to produce a closer match to a desired paint color.

II. **Color matching**

A. New paints and new factory application techniques have greatly increased the variables that can influence the match of paint when refinishing a vehicle.

B. Although vehicle manufacturers, through paint suppliers, provide matching paint for each vehicle they produce, the paint does not always match because there are too many variables.

C. Some variables influencing color shifts

1. Age of the vehicle (The older the vehicle the more chance for a color shift due to the effects of sunlight.)

2. Application techniques of the body repairman

(NOTE: Application techniques are extremely important in the case of metallic paints.)

a. Incorrect or incomplete surface preparation, such as failure to use a sealer when required

b. Applying paint too thick or too thin, too wet or too dry, which can cause a dramatic color shift

c. Incorrect gun distance, gun speed, or incorrect flash time between coats

d. Using too much air pressure, which lightens color, or using too little air pressure, which darkens color

e. Using the incorrect thinner or reducer, incorrect ratio of thinner or reducer, or incomplete mixing

f. Incorrect spray gun adjustments for type of paint being sprayed

g. Temperature, humidity and ventilation conditions of the shop

3. Color coat application techniques of the manufacturer

a. High solids and waterborne topcoats are used in some factory applications, but are not available for body shop use

b. Electrostatic painting and automatic (robot) painting are used in some factory applications, but are not available for body shop use

(NOTE: Although the methods above are not available for use in the body shop, paint still can be matched.)

4. Wax buildup

D. Procedures for achieving a correct color match

1. Changing gun settings of techniques, or changing solvent (if recommended). These procedures should be tried first, if practical.

2. Blending, which should be attempted before tinting.

3. Tinting, which should only be used if other procedures will not work.

III. Blending

(NOTE: In blending paint, follow the paint manufacturer's recommendations. Procedures will vary slighty from the following for some enamels and clearcoat systems.)

A. Prepare entire adjacent panel or panels for blending – make sure you prepare a large enough area

B. You must be prepared to blend across dividing lines, such as door-fender gaps

C. You must prepare surface of blending area in this sequence:

1. Wash with water

2. Clean with wax-and-grease remover

3. Compound surface

4. Reclean with wax-and-grease remover

(NOTE: Rubbing compound leaves behind residues which must be removed.)

D. You must always use clean, white rags in preparation steps.

E. If applying a two-stage or three-stage system, consult paint manufacturer's recommendations. A sealer may be required.

F. You must decide if the paint is close enough to blend.

1. Compare a sample of the paint with the surface to be matched

2. If it seems close enough to blend, check further by spraying some new paint onto a test panel, allowing it to dry, and comparing it with the surface to be matched.

   (NOTE: It is best to make comparisons in both natural light and artificial light. They should compare favorably under both conditions or there may be a problem.)

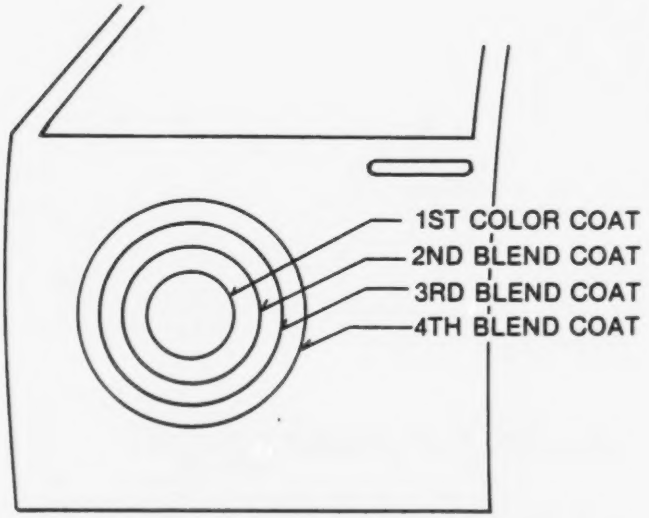
3. If the paint is not close enough to blend, you must tint the paint.

G. Applying the blend

1. Spray repaired area with arcing stroke until proper hiding and film thickness is achieved. Using check-hiding labels is a good idea, especially if using a two- or three-stage system.

2. Graduate color onto surrounding surface, allowing each coat to overlap the previous application. (FIG. 1-1)

FIGURE 1-1



3. If that doesn't work because color is too far off, then take a small amount of the paint you've been applying and add a 1:1 ratio of clear. To the resulting mixture, add a 1:1 ratio of recommended thinner or reducer.

4. Spray the resulting mixture over and beyond the previous application. The addition of the clear allows the old color and the new color to show through together and, thus, blend.

5. If this application still does not provide an adequate blend, repeat the procedure

   a. Take a small amount of the paint applied in the second application, add a 1:1 ratio of clear, then to the resulting mixture add a 1:1 ratio of recommended thinner or reducer.

   b. Repeat blending application.

   c. Reapeat procedure again, if needed.

6. After successfully blending, apply two or three coats of clear overlay by mixing clear in a 2:3 ratio with recommended thinner or reducer.

IV. Tinting

(NOTE: When you tint, tint in order to find a color match that can be blended. DO NOT try to tint for a perfect match.)

A. There are three characteristics of any color

   1. Lightness or darkness (called depth)

   2. Cast differences, which are described in terms of the following four colors:

      a. Redder cast

      b. Bluer cast

      c. Greener cast

      d. Yellower cast

   3. Cleanliness (brightness or grayness)

B. Changing a tint must be done in the order of depth-cast-cleanliness.

   1. Adjust the depth first, if needed

   2. Adjust the cast next, if needed

   3. Adjust cleanliness last

C. In making a judgment, ask yourself how the car's color compares to the paint you are trying to match it with.

   1. If the car is darker, for example, you must make the paint darker.

   2. If the car is greener, for example, you must make the paint greener.

   3. If the car is grayer, you must make the paint grayer.

D. When evaluating metallic colors or pearls, you must check the match, using a test panel, from various angles because metallic colors and pearls change appearance depending on the angle at which they are viewed.

E. The first step is to adjust the lightness or darkness of the paint, which is done by controlling a number variables that have nothing to do with the actual cast of the paint.

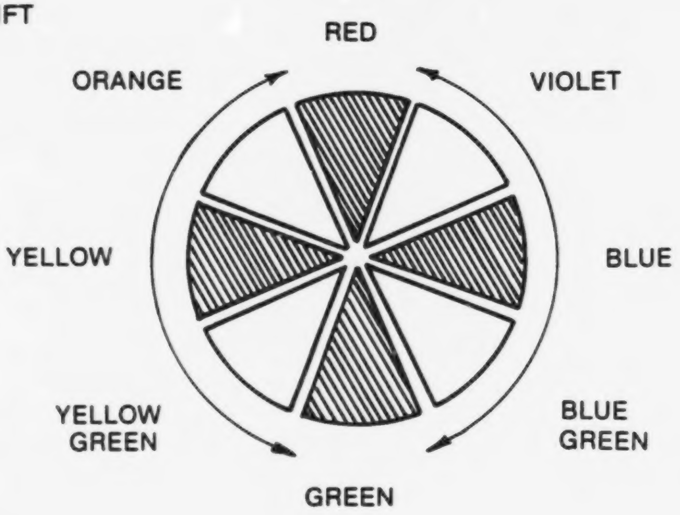
1. The following will make paint lighter:
    a. Increase temperature of paint room.
    b. Decrease humidity of paint room.
    c. Increase ventilation of paint room.
    d. Increase gun distance.
    e. Increase gun speed.
    f. Allow more flash time between coats.
    g. Use a faster drying thinner.
    h. Increase amount of thinner.
    i. Use a smaller fluid tip.
    j. Use an air cap with more holes.
    k. Decrease material flow.
    l. Increase fan width.
    m. Increase air pressure.
2. The following will make paint darker:
    a. Decrease temperature of paint room.
    b. Increase humidity of paint room.
    c. Decrease ventilation of paint room.
    d. Decrease gun distance.
    e. Decrease gun speed.
    f. Allow less flash time between coats.
    g. Use a slower thinner.
    h. Decrease amount of thinner.
    i. Use a larger fluid tip.
    j. Use an air cap with fewer holes.
    k. Increase material flow.

- l. Decrease fan width.
- m. Decrease air pressure.
- n. Use a wetter mist coat.
- o. Add retarder.

V. **Changing cast**

- A. When tinting, only pure base colors (also called toners) must be used
- B. Intermix formulas, available with intermix system or from paint jobber, show exactly what colors are used in each color of paint.
- C. For example, you may have to make a paint greener and the intermix formula can tell you which of several greens to use.
- D. Colors fall into one of four cast shifts. All automotive paints can be tinted by thinking in terms of these four shifts.
  - 1. Red-Green (FIG. 1-2)

FIGURE 1-2
RED-GREEN SHIFT



- a. Can make colors in this shift only redder or greener by adding red or green
- b. Colors in red-green shift are blues, golds, yellows, purples, beiges and browns

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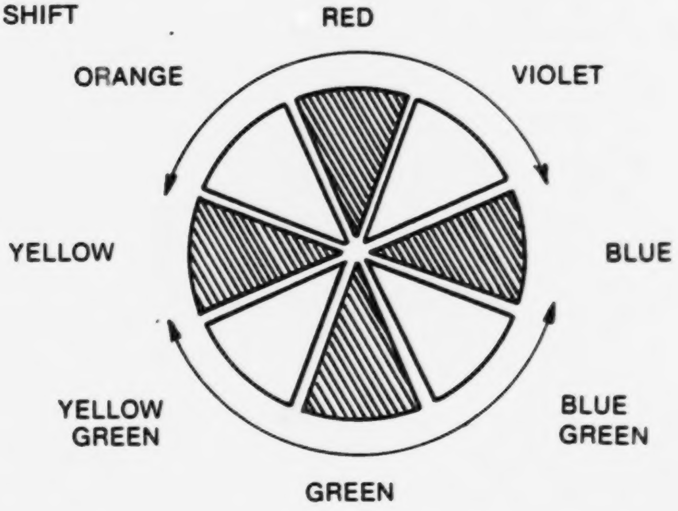
2. Yellow-blue (FIG. 1-3)

FIGURE 1-3
YELLOW-BLUE SHIFT

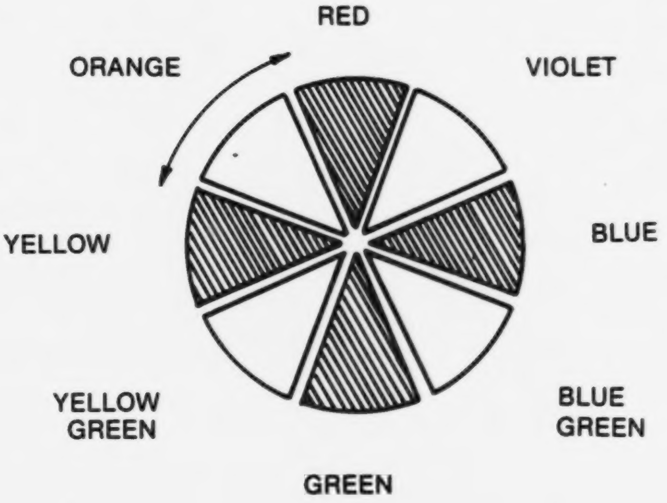

RED
ORANGE
VIOLET
YELLOW
BLUE
YELLOW GREEN
BLUE GREEN
GREEN

a. Can make colors in this shift only yellower or bluer by adding yellow or blue

b. Colors in yellow-blue shift are greens, off-whites, maroons, blacks, whites, grays

3. Yellow-red shift (FIG. 1-4)

FIGURE 1-4
RED-YELLOW

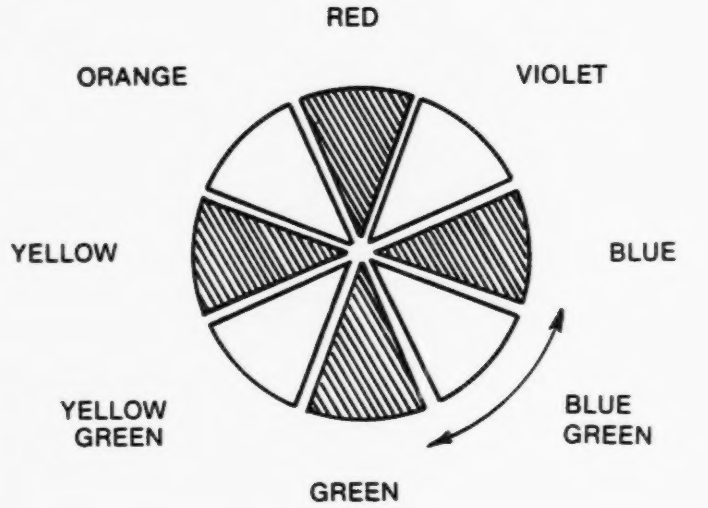

RED
ORANGE
VIOLET
YELLOW
BLUE
YELLOW GREEN
BLUE GREEN
GREEN

a. Can make colors in this shift only yellower or redder by adding yellow or red

b. Colors in yellow-red shift are bronzes, oranges and reds

4. Blue-green shift (FIG. 1-5)

FIGURE 1-5
BLUE-GREEN



a. Can make colors in this shift only bluer or greener by adding blue or green

b. Colors in blue-green shift are aquas, jadestones, turquoises.

E. Proper tinting methods

1. Start with only a small amount of paint to be tinted. Overtinted paint will have to be discarded.

2. Add only a small amount of the determined color.

3. Mix paint, spray, allow to dry and compare.

4. Add another small amount, mix, spray and compare.

3. Repeat and record all amounts added until you achieve a shift which can be blended. Make notes such that you can mix the larger amount needed in the same way.

4. After achieving a shift which can be blended, check it by mixing part of the sample and spraying it on a test panel.

5. If test panel shows a good match, including views from all angles and in both natural and artificial light, then mix the entire amount of paint needed, following the same proportions used in the test sample.

UNIT V

JOB SHEET #1, LESSON ONE

TINT AND BLEND COLOR COAT

Equipment:

OEM paint
Proper primer
Proper thinner/reducer
Test panel
Intermix colors
Wax and grease remover
Water
Compound
Buffer
Masking tape
Sandpaper
Spray gun
Proper safety equipment

Procedure:

Evaluation:
3 2 1 N

1. Prepare panel repair by performing Job Sheet #1, Lesson Two, Unit III. ___ ___ ___ ___

2. Prepare entire adjacent panel or panels for blending in this sequence: ___ ___ ___ ___

    a. Wash with water

    b. Clean with wax-and-grease remover

    c. Compound surface

    d. Reclean with wax-and-grease remover

3. Prime repaired area with proper primer. ___ ___ ___ ___

4. Sand primed area and re-prime or use spot putty as needed. ___ ___ ___ ___

5. Seal area to be blended according to paint manufacturer's recommendations. ___ ___ ___ ___

6. Select finish, compare color and determine color shifts required. ___ ___ ___ ___

7. Tint small amount of color, carefully recording tint procedure until satisfactory match is completed. ___ ___ ___ ___

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
8. Tint rest of paint for complete job and compare match. Then prepare surface for painting following paint manufacturer's recommendations.	___	___	___	___
9. Apply first blend coat with proper technique.	___	___	___	___
10. Reduce small amount of color coat 1:1 with clear. Reduce resulting mixture 1:1 with recommended thinner or reducer.	___	___	___	___
11. Spray resulting mixture with proper technique over blended area and onto adjacent surfaces enough to make a successful blend.	___	___	___	___
12. Repeat steps 10 and 11, if needed.	___	___	___	___
13. Apply two to three coats clear overlay over blended area and a few inches beyond.	___	___	___	___
14. Allow to dry, remove masking tape and compound or color sand surface according to paint manufacturer's recommendations.	___	___	___	___
Average of above evaluations*	___	___	___	___

(Note: This average is the evaluation for competency M14 "Tint and blend color coat.")

MODULE: REFINISHING

UNIT V: SPECIAL APPLICATIONS

LESSON TWO: SPECIAL APPLICATIONS

I. **Terms and definitions**

   A. Aftermarket paint protection -- Special wax-type applications applied by some vehicle dealers upon the sale of the vehicle.

   B. Chip-resistant coating -- Any thick vinyl or plastisol paint applied to the lower body panels of vehicles to resist chips from road hazards.

   C. Flexible paint -- Paint to which an additive has been mixed, making the paint film capable of bending without cracking.

   D. Texture material -- A sprayable material which is used to restore and match the texture of vinyl and plastic interior components following the repair of such components.

II. **Special paints and paint products**

   A. Aftermarket paint protection

      1. If present, special care must be taken to ensure that wax and grease remover completely removes these special waxes

      2. If paint protection is to be replaced, replace with identical brand and follow manufacturer's recommendations.

   B. Chip-resistant coatings

      1. If present, must be replaced during refinishing operations

         a. Must be ground or sanded off (due to thickness, grinding will be used in cases where it must be removed completely)

         b. If only minor imperfections need attention, consult coating manufacturer's recommendations.

      2. Many different brands available -- often called gravel guard

      3. Must be applied after primer-surfacer and sealer and before topcoat

      4. Is available as solvent-borne, spraying material

      5. Apply according to manufacturer's recommendations

      6. Usually requires heat lamp or heat gun to cure material

   C. Flexible panels and flexible paint

      1. Many soft plastic parts for exterior or cosmetic application are made of resins with flexible characteristics.

2. In refinishing flexible panels the paint must also be flexible.

3. Most factory applications use flexible enamel paint. However, either lacquer or enamel may be used for repairs.

4. Undercoats, if used, as well as topcoats, must be flexible.

5. General Motors states that any flexible primer may be used unless the material to be painted is E/P or TPO, in which case a polypropylene primer must be used.

   (NOTE: Some paint manufacturers specify specific primers and topcoats for specific flexible materials. Consult paint manufacturer whose products you are using and follow their recommendations.)

6. Flexible paints are generally formed by adding additives to either lacquer or enamel paints.

   (CAUTION: *These additives may contain isocyanates. If the paint system selected specifies such an additive it is mandatory that an adequate respirator be worn. An air-supplied respirator is recommended. If not available, use a respirator that is approved for used with isocyanate vapors and mists.)*

7. The entire panel must be color-coated -- spot repair is not recommended. The entire panel must be sanded with 400 sandpaper, removing all gloss.

D. Painting stripes

1. Use special pinstripe masking tape.

2. Correct size tape is applied to painted surface and pre-cut pullout stripe is removed from center of tape.

3. Use solid colors only.

4. Spray with air brush or conventional spray gun.

5. If using conventional spray gun, set spray for small round pattern with low air pressure of about 20 psi.

6. Enamel paint usually recommended - remove tape when tacky.

7. Be sure to mask all adjacent surfaces even if using an air brush.

8. Spray with light to medium first coat and finish with wet coat.

E. Texture material

1. In modern collision repair, certain plastic components are now being repaired with plastic welding procedures (See Module 3, "Panel Repairs.")

2. The repair operation of welding plastic leaves a smooth surface which does not match the textured surface of the unrepaired portion of the part.

3. Texture material is a flexible paint which will restore and match the texture of repaired interior components, such as dashboards.

4. The more the material is thinned, the smaller the grain produced, allowing a proper match.

5. Procedure for applying texture material is much like the procedure for blending a color coat.

   a. Spray material on repair.

   b. Thin material and re-spray until proper texture match is achieved.

   c. When repaired area's texture closely matches that of the unrepaired area, spray material out farther on the unrepaired area.

   d. If needed, thin material more and blend again until texture appears uniform.

   e. After applying texture, sand with recommended sandpaper to produce smoother texture.

   f. If texture material does not match repaired area, entire area can be sprayed or tinting and blending can be performed using flexible paint.

   g. Follow all texture material manufacturer's recommendations on surface preparation and application.

UNIT V

JOB SHEET #1, LESSON TWO

APPLY CHIP RESISTANT COATING

Equipment:

Chip-resistant coating
50-grit sandpaper
Sanding block
Heat lamp or heat gun
Tack rag

Procedure:

		Evaluation: 3	2	1	N
1.	Prepare surface of coating by sanding with 50-grit sandpaper.	___	___	___	___
2.	Mask off area of panel to receive coating and mask overspray areas.	___	___	___	___
3.	Mix chip resistant coating following manufacturer's recommendations.	___	___	___	___
4.	Test paint on test panel.	___	___	___	___
5.	Tack surface and spray chip resistant coating, following manufacturer's recommendations.	___	___	___	___
6.	Use heat gun or appropriate heat lamp to cure coating, following coating manufacturer's recommendations.	___	___	___	___
	Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency M15 "Apply chip-resistant coating.")

UNIT V

JOB SHEET #2, LESSON TWO

MIX AND APPLY FLEXIBLE PAINT SYSTEM

Equipment:

Proper paint with flexible additives
Proper primer
Proper thinner/reducer
Flexible panel
Wax and grease remover
Water
Masking tape
Sandpaper
Spray gun
Proper safety equipment

Procedure:

	Evaluation: 3	2	1	N
1. Prepare panel repair by performing Job Sheet #1, Lesson Two, Unit III.	___	___	___	___
2. Prepare entire panel for refinishing by performing this sequence:	___	___	___	___
a. Wash with water.				
b. Clean with wax-and-grease remover and wipe dry.				
3. Mask adjacent areas which must be protected.	___	___	___	___
4. Put on proper safety equipment and prime repaired area with proper primer, applying four coats and allowing recommended flash time between coats.	___	___	___	___
5. Allow to dry at least one hour and block sand with 400 sandpaper, thoroughly sanding entire surface and removing all gloss.	___	___	___	___
6. Re-clean with wax and grease remover and wipe dry.	___	___	___	___
7. Mix color, flexible additive and solvent according to paint manufacturer's recommendations.	___	___	___	___
8. Apply topcoat, giving a sufficient number of coats for complete hiding and color match.	___	___	___	___

Procedure:	Evaluation: 3 2 1 N
9. Allow to dry, remove masking tape and compound/color sand surface according to paint manufacturer's recommendations.	___ ___ ___ ___
Average of above evaluations*	___ ___ ___ ___

(Note: This average is the evaluation for competency M16 "Mix and apply flexible paint system.")

UNIT V

JOB SHEET #3, LESSON TWO

MASK AND PAINT STRIPES

Equipment:

Pinstripe masking tape
Recommended enamel paint
Recommended reducer
Spray gun
Masking tape and paper
Tack rag
Buffer
Proper safety equipment

Procedure:		**Evaluation:** 3	2	1	N
1.	Buff surface to receive stripes with recommended compound.				
2.	Apply pinstripe masking tape carefully, using natural breaks as a guide.				
3.	Carefully remove cutout from pinstripe masking tape.				
4.	Mask adjacent panels and any areas likely to receive overspray.				
5.	Mix paint, following paint manufacturer's recommendations.				
6.	Tack surface exposed by cutout in tape.				
7.	Adjust spray pressure to 20 psi and adjust spray pattern to small round area.				
8.	Apply paint using one light-to-medium coat and one heavy coat.				
9.	After paint on surface of tape has become sticky to the touch, carefully remove tape.				
	Average of above evaluations*				

(*This average may be used as the evaluation for competency M3, "Demonstrate appropriate masking techniques.")

UNIT V

JOB SHEET #4, LESSON TWO

RE-TEXTURE PLASTIC DASH PANEL

Equipment:

Plastic interior component which has been plastic welded
Texture material
Spray gun
Proper thinner/reducer
Adhesion promoter, if required
Appropriate sandpaper
Safety goggles
Rubber gloves
Recommended respirator

Procedure: **Evaluation:** 3 2 1 N

1. Perform plastic repairs by performing appropriate Job Sheet in Plastic Repairs Unit of Module 3: Panel Repairs. ___ ___ ___ ___
2. Scuff sand area with recommended sandpaper. ___ ___ ___ ___
3. Apply texture material per manufacturer's recommendations. ___ ___ ___ ___
4. When texture match is achieved, blend repair area into unrepaired area. ___ ___ ___ ___
5. Allow texture material to dry, then scuff sand with recommended sandpaper to flatten the sprayed texture. ___ ___ ___ ___
6. Refinish component with appropriate matching, flexible paint, if required. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for competency H7, "Repair and re-texture plastic dash panel.")

MODULE: PAINT AND REFINISHING

UNIT V: SPECIAL APPLICATIONS

UNIT V TEST

PART I—COLOR MATCHING

I. Select the best answer from the choices listed.

_____1. Camouflage of slightly mismatched paint

_____2. The dominant pigments of a color

_____3. Change in the appearance of paint

_____4. Lightness or darkness of a color

_____5. The brightness or grayness of a color

_____6. Addition of base colors to change cast

A. Depth

B. Spot color

C. Cast

D. Blend

E. Tint

AB. Cleanliness

AC. Color shift

II. Select the best answer from the choices listed.

_____7. A reason paint does not always match, even though the correct paint was mixed is: (a) age of the vehicle, (b) spray techniques of repairman, (c) spray techniques of vehicle manufacturer, (d) metallic flake pitch angle, (e) all of the above.

_____8. Which of the following is not a spray application technique which can influence color match? (a) brand of siphon-feed spray gun, (b) apply paint too thick, (c) using too much air pressure, (d) using the wrong thinner, (e) wrong flashing between coats.

_____9. When you are trying to tint paint, you are trying to get: (a) a perfect match, (b) a blendable match, (c) a tintable match, (d) the correct cast, (e) the correct tint.

_____10. In order to check whether paddle paint is close enough to blend, it is best to (a) hold paint paddle next to dry panel, (b) hold dry paint paddle next to wetted panel, (c) hold dry paint paddle next to dry panel, (d) spray test panel, allow to dry, and compare with dry panel, (e) spray test panel, allow to dry, and compare with wetted panel.

_____11. If a first attempt at blending doesn't work, you must: (a) start over, (b) mix in clear, (c) re-tint, (d) re-tint and add clear, (e) paint entire panel.

_____12. After a successful blend, the final step is to: (a) apply clear, (b) compound, (c) color sand, (d) apply clear sealer, (e) apply wax.

_____13. The order of adjustments in changing a tint is: (a) cast/depth/cleanliness, (b) cast/cleanliness/depth, (c) depth/cleanliness/cast, (d) depth/cast/cleanliness, (e) cleanliness/depth/cast.

_____14. Which of the following is NOT one of the four major cast shifts? (a) red/green, (b) yellow/blue, (c)red/blue, (d) yellow/red, (e) blue/green.

III. Mark a T on the test or answer sheet if the statement is true and an F if the statement is false.

_____15. You must never blend across natural breaks, such as door openings.

_____16. Paint should be compared for matching in artificial light.

_____17. Blending applications use an arcing stroke.

_____18. You should check the match of metallic color by viewing it from several angles.

_____19. You should start tinting only a small amount of paint.

_____20. You must add small amounts of color in making a tint and carefully record the amount added.

(NOTE: Completion of part one of this unit test with a minimum score of _____ is necessary for the student to receive evaluations on Job Sheet #1, Lesson 1.)

PART II--SPECIAL APPLICATIONS

I. Mark a T on the test or answer sheet if the statement is true and an F if the statement is false.

_____21. Aftermarket paint protection is a type of wax.

_____22. Chip-resistant coating is a type of texture material.

_____23. Chip-resistant coating is found on lower panels of some vehicles.

_____24. You must never use a heat lamp or gun on chip resistant coatings.

_____25. Flexible paint may be made from either enamel or lacquer paint by adding flexible additives.

_____26. Flexible paint may require an air-supply respirator for spraying.

_____27. In spraying flexible paints, you must paint the entire panel and should not make a spot repair.

_____28. If spray-painting stripes, you should set the spray for a small, round pattern, with a low air pressure of about 20 pounds.

_____29. Texture material will produce a larger grain the more it is thinned.

_____30. Texture material is used in repairing interior components.

(NOTE: Completion of part two of this unit test with a minimum score of _____ is necessary for the students to receive evaluations on Job Sheets 1, 2, 3, 4, and 5, in Lesson 2, Unit V.)

ANSWERS TO UNIT V TEST

PART I.

1. D
2. C
3. AC
4. A
5. AB
6. E

7. E
8. A
9. B
10. D
11. B
12. A
13. D
14. C

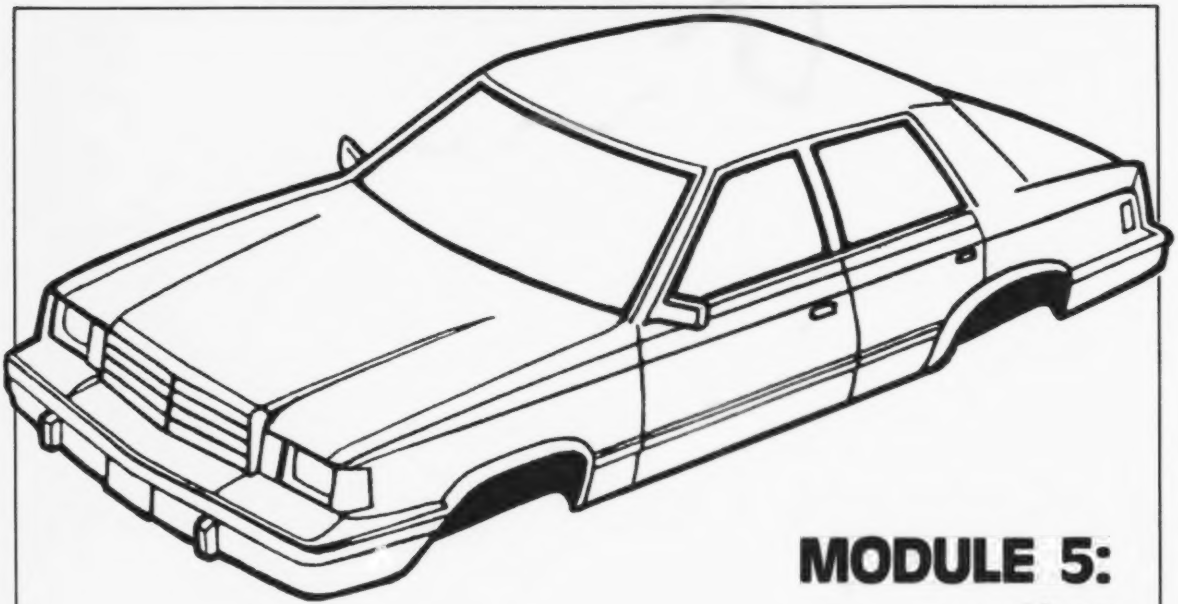
15. F
16. F
17. T
18. T
19. T
20. T

PART II.

21. T
22. F
23. T
24. F
25. T
26. T
27. T
28. T
29. F
30. T

Auto Body Repair Curriculum Guide

INSTRUCTOR'S GUIDE



MODULE 5:

- Glass
- Exterior Molding and Trim
- Fasteners
- Vinyl Tops and Decals
- Interior Repairs
- Safety

Exterior and Interior Trim

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AUTO BODY CURRICULUM
Instructor's guide

MODULE 5:
EXTERIOR AND INTERIOR TRIM

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Auto Body

Exterior and Interior Trim

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N 2	I	1-X					34-45	
N 3	I	1-IX					46-55	
N 4	I	2-I					56-64	
O 1	I	2-IIa				1		
O 2	I	2-IIb				2		
O 3	I	2-IIc				3		
O 4	I	2-IId				4		
O 5	I	2-IIe				5		
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Q 3	III	2-I--2-IV				2	13-22	
Q 4	III	2-I--2-IV				3	13-22	
Q 5	III	2-I--2-IV				4	13-22	
Q 6	III	2-I--2-IV				5	13-22	

Auto Body

Exterior and Interior Trim (continued)

Cross-Reference Table of Instructional Materials

Competency	Unit	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
Q 7	III	3-I--3-II				1	33-40	
Q 8	III	3-I--3-II				2	33-40	
Q 9	III	3-V				5		
Q 10	III	3-V				6		
Q 11	III	3-IV				4		
Q 12	III	3-III				3		
R 1	IV	1-I--1-IV					1-39	
		2-1--2-II	1-3					
		3-I--3-VI	1-2					
R 2	IV	2-IIIa	1			1	1-39	
R 3	IV	2-IIIb	1			2	1-39	
R 4	IV	2-IIIc	1-3			3	1-39	
R 5	IV	2-IIId	1-3			4	1-39	
R 6	IV	2-IIIe				5		
R 7	IV	3-VII a,b	2			1-2	1-39	
R 8	IV	3-VIIc	2			3	1-39	
R 9	IV	3-VIId				4	1-39	
R 10	IV	3-VII e,f				6	1-39	
R 11	IV	3-VIIg				7	1-39	

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT I: EXTERIOR TRIM

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify the fasteners used in vehicle construction and service trim and trim fasteners. Mastery will be evidenced through demonstration and by scoring ______ per cent on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Match terms with their definitions or illustrations (Competencies N1-N4, Unit I test)

II. Identify types of bolts (Competency N1, Part I of Unit I test)

III. Identify types of studs (Competency N1, Part I of Unit I test)

IV. Identify types of nuts (Competency N1, Part I of Unit I test)

V. Identify types of washers (Competency N1, Part I of Unit I test)

VI. Identify bolt size designations (Competency N1, Part I of Unit I test)

VII. Identify prevailing torque fasteners (Competency N1, Part I of Unit I test)

VIII. Identify removal methods for bolts and nuts (Competency N1, Part I of Unit I test)

IX. Identify types screws (Competency N3, Part III of Unit I test)

X. Identify types of rivets (Competency N2, Part II of Unit I test)

XI. Identify miscellaneous fasteners (No competency)

Lesson 2:

I. Identify types of clips (Competency N4, Part IV of Unit I test)

II. Demonstrate the ability to:

  a. Remove and replace belt molding and trim (Competency O1, Job Sheet #1)

  b. Remove and replace driprail scalp molding and trim (Competency O2, Job Sheet #2)

  c. Remove and install glue-on molding and trim (Competency O3, Job Sheet #3)

  d. Locate and drill holes for molding and trim (Competency O4, Job Sheet #4)

e. Use weld-on stud gun to install molding (Competency O5, Job Sheet #5)

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT I: EXTERIOR TRIM

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of unit

C. References

D. Lesson plans

  1. Lesson 1: Threaded and Mechanical Fasteners

    a. Information outline

  2. Lesson 2: Trim Fasteners

    a. Information outline

    b. Job sheets

      JS#1: Remove and replace belt molding and trim
      JS#2: Remove and replace driprail scalp molding and trim
      JS#3: Remove and replace glue-on molding and trim
      JS#4: Locate and drill holes for molding and trim
      JS#5: Use weld-on stud gun to install molding

E. Unit test

F. Answers to unit test

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1. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

2. Czapskie, George S., et. al. *Auto Body Repair.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1977.

3. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL. 1984.

4. General Motors Corporation. *1987 Body Service Manual (Buick, Oldsmobile, Cadillac).* General Motors Corporation. 1986.

5. Litton, Bill, and Sharpton, James. *Introduction to Auto Body.* Curriculum & Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education. Stillwater, OK. 1985.

6. Mitchell Information Services, Inc. *Body and Mechanical Parts Service & Repair, Domestic Cars, 1981-85.* Mitchell Information Services. San Diego, CA. 1985.

7. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

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MODULE: EXTERIOR AND INTERIORTRIM

UNIT I: EXTERIOR TRIM

LESSON ONE: THREADED AND MECHANICAL FASTENERS

I. **Terms and definitions**

A. Acorn nut -- Nut with domed hex head.

B. Bolt -- A bolt is a fastener threaded on the outside, with a head at one end and threads at the other. They use a nut on the threaded end.

C. Coarse threads -- Unified National Coarse (UNC) or United States Standard (USS) threads. Used on bolts and nuts that will hold soft or crumbly metals.

D. Fine thread -- Unified National Fine (UNF) or Society of Automotive Engineers (SAE) threads used on bolts and nuts that will need great strength and a close fit.

E. Hex head -- Nut, screw or bolt head with a six-sided (hexagonal) shape.

F. Nut -- A nut is a removable fastener used with a bolt or stud to hold parts together. Nuts are threaded on the inside.

G. Right-hand threads -- Thread designation telling that a bolt or nut is tightened by turning in a clockwise direction. Most nuts and bolts have right-hand threads.

H. Screw -- A screw is a threaded fastener with a head at one end and threads at the other end. It differs from a bolt because it uses no nut.

I. Self-locking nut -- Nut designed to lock itself to a bolt to prevent loosening caused by vibration.

J. Self-tapping thread -- Bolt or screw that cuts its own threads in a drilled hole.

K. Slotted hex nut -- A hexagonal nut with slots cut into the top, designed for use with a cotter pin. Also called a castle nut.

L. USCS -- United States Customary System, the standard designation of non-metric bolts, nuts and studs.

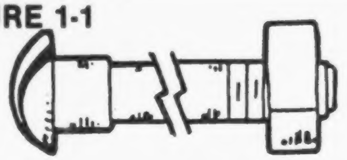
M. Washer -- A washer is a thin, flat part, usually metal, with a hole in the center through which a bolt, stud or screw can pass. Common washers are used under nut and bolt heads to provide a smooth load-bearing surface and to act as a shim. Lock washers use a variety of designs to help prevent the fastener from loosening.

N. Wing nut -- A type of nut with opposing "wings" formed on it, designed to be tightened by hand.

II. Types of bolts

A. Carriage bolt (FIG. 1-1)

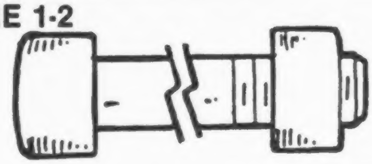
FIGURE 1-1



1. Round head
2. Square shank
3. Used to fasten inner-body panel stiffeners to cross rails

B. Machine bolt (FIG. 1-2)

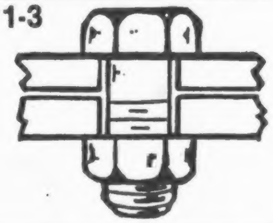
FIGURE 1-2



1. Square head
2. Round shank
3. Commonly used to fasten mechanical parts to stationary body panels

C. Hex bolt and nut (FIG. 1-3)

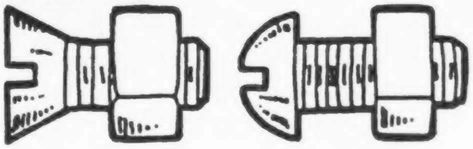
FIGURE 1-3



1. Hex head
2. Either coarse or fine thread

D. Stove bolts (FIG. 1-4)

FIGURE 1-4

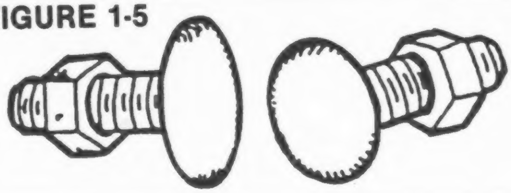


1. Either round or flat heads

2. Threading runs all the way to head

E. Bumper bolts (FIG. 1-5)

FIGURE 1-5



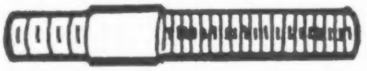
1. Elliptical or round, chrome head

2. Hex nut

3. Used to fasten bumpers to energy absorbers

III. **Studs** (FIG. 1-6)

FIGURE 1-6



A. Studs are threaded fasteners with threads at both ends on the outside and no head.

B. Usually have fine threads on one end and coarse threads on the other end

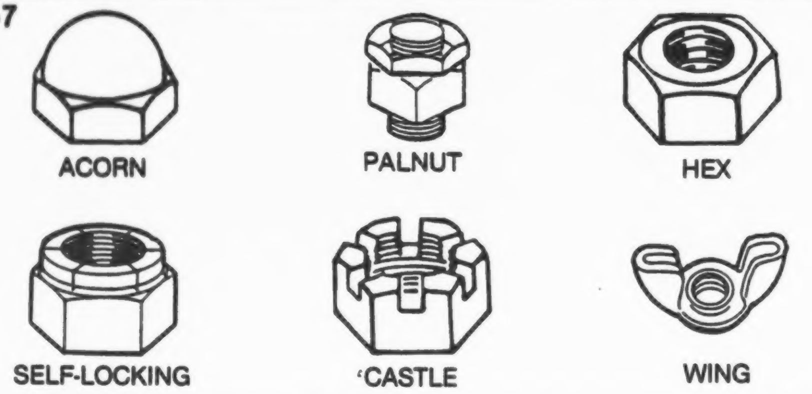
C. Generally used to attach one casting to another

D. Usually threaded into one casting, with the other casting attached by a nut

IV. **Types of nuts** (FIG. 1-7)

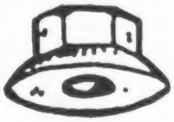
A. Common nuts -- A variety of styles

FIGURE 1-7


ACORN
PALNUT
HEX
SELF-LOCKING
'CASTLE
WING

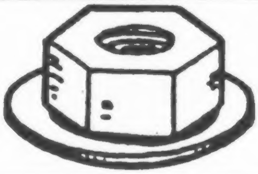
B. Flanged hex nuts -- Standard hex nut with a flanged, heavy washer formed as part of the nut. (FIG. 1-8)

FIGURE 1-8



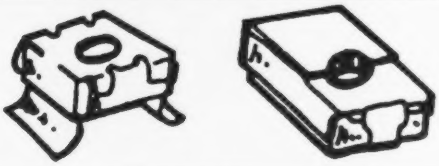
C. Washer nuts -- Standard hex nuts with flat, heavy washers formed as part of the nut. (FIG. 1-9)

FIGURE 1-9



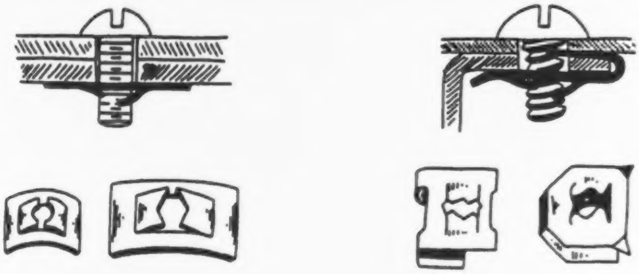
D. Retainer nuts -- Snapped into various body panels and support assemblies to allow bolts to be inserted into blind holes and tightened without access. (FIG. 1-10)

FIGURE 1-10



E. Speed nuts -- Attached to light-gauge, non-supporting metal panels and skirts in areas where no panel strength is required. (FIG. 1-11)

FIGURE 1-11



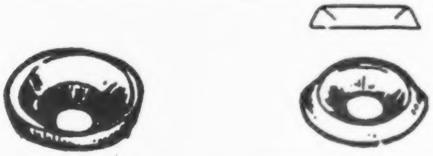
FLAT TYPE

J TYPE

V. **Types of washers**

A. Finishing washers (FIG. 1-12)

FIGURE 1-12

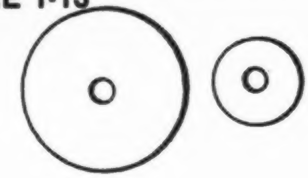


1. Decorative washers used with screws
2. Used on garnish moldings and other interior trim assemblies, such as seat backs, skirts, and seat belt trim

748

B. Flat steel washers (FIG. 1-13)

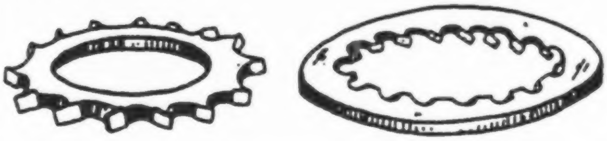
FIGURE 1-13



1. Used as spacers or reinforcement
2. Used on body-panel assemblies and mechanical system attachment points.

C. Shakeproof lock washers (FIG. 1-14)

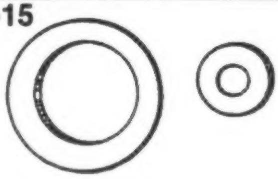
FIGURE 1-14



1. Have teeth, which fasten against the bolt
2. Used in areas where vibration can loosen the fastener

D. Fender washers (FIG. 1-15)

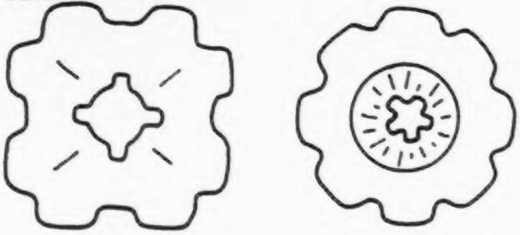
FIGURE 1-15



1. Like flat steel washers, but have narrowed, flat surface between center hole and outer edge

E. Body washers (FIG. 1-16)

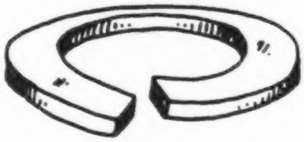
FIGURE 1-16



1. Normally concave, so that fastener creates pressure at outer edge as it is tightened.
2. Used to prevent body panel from shifting

F. Spring lock washers (FIG. 1-17)

FIGURE 1-17

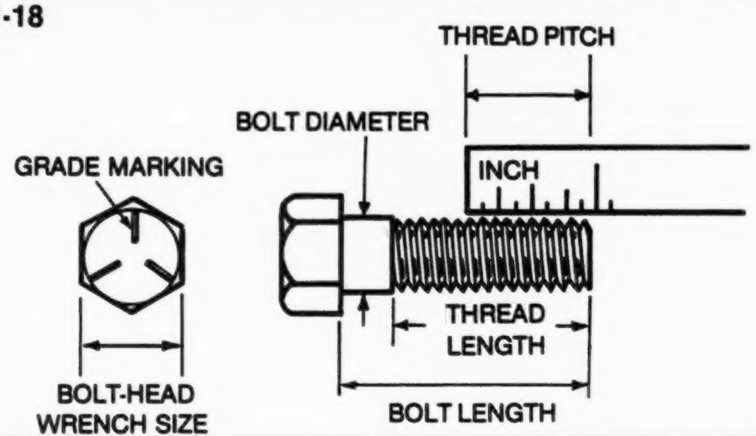


1. Split with ends bent in opposite directions
2. Spring and gripping action of washer prevents loosening of fastener

VI. Measurement designations for bolts (FIG. 1-18)

(NOTE: Metric and USCS fasteners are NOT interchangeable, even though some sizes are almost the same. Metric fasteners are measured in millimeters. The following designations apply to both metric and USCS, with any differences noted.)

FIGURE 1-18


THREAD PITCH
BOLT DIAMETER
GRADE MARKING
INCH
THREAD LENGTH
BOLT-HEAD WRENCH SIZE
BOLT LENGTH

A. Bolt diameter

B. Bolt-head wrench size

C. Bolt length

D. Thread length

E. Thread pitch

  1. Number of threads per inch for USCS

  2. Distance between threads, measured crest to crest in millimeters, for metric

  3. Measured by thread gauge or counting

F. Thread class

  1. Three measures of the closeness of fit

    a. Class 1 -- loosest fit

    b. Class 2 -- tighter fit

    c. Class 3 -- very close fit

  2. Two designations of location of thread

    a. A-thread - external thread

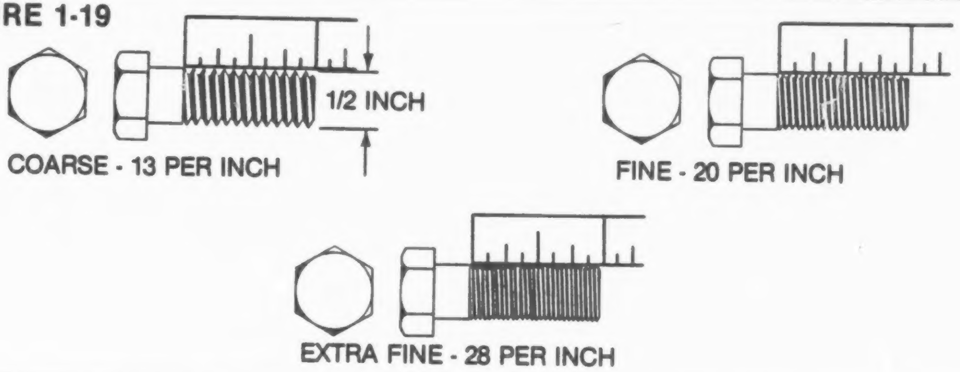
    b. B-thread - internal thread

751

G. Thread series (FIG. 1-19)

1. Coarse
2. Fine
3. Extra-fine

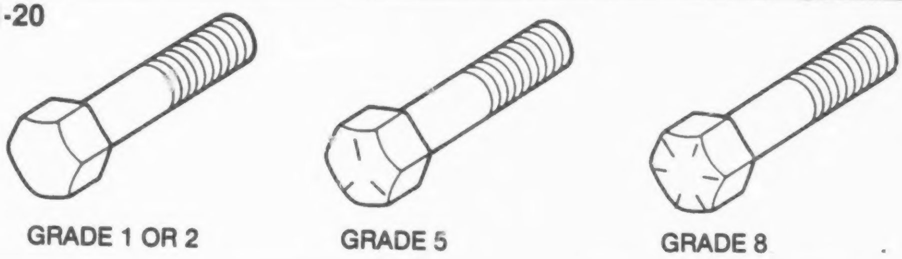
FIGURE 1-19


1/2 INCH
COARSE - 13 PER INCH
FINE - 20 PER INCH
EXTRA FINE - 28 PER INCH

H. Fastener strength markings

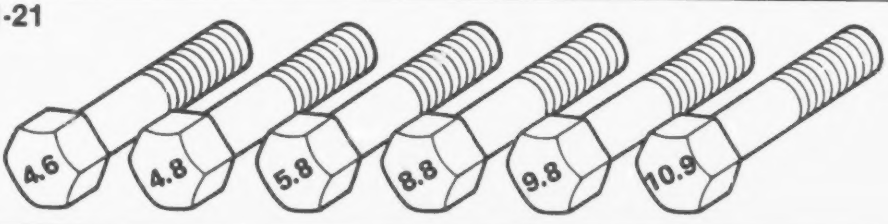
1. Used on bolts and hex-head screws, nuts and studs
2. Marked on head of bolt or screw
    a. USCS -- the more slash marks, the stronger (FIG. 1-20)

FIGURE 1-20


GRADE 1 OR 2
GRADE 5
GRADE 8

    b. Metric - the higher the number, the stronger (FIG. 1-21)

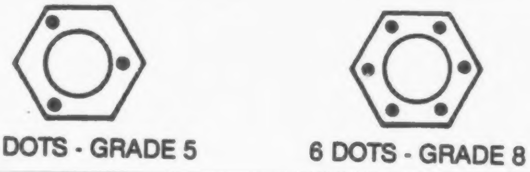
FIGURE 1-21


4.6
4.8
5.8
8.8
9.8
10.9

3. Marked on rim of nut

   a. USCS - the more dots, the stronger (FIG. 1-22)

FIGURE 1-22

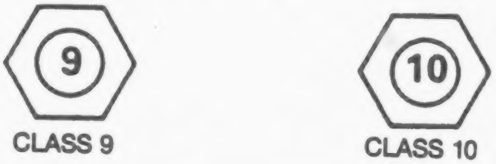


3 DOTS - GRADE 5

6 DOTS - GRADE 8

   b. Metric - the higher the number, the stronger (FIG. 1-23)

FIGURE 1-23



CLASS 9

CLASS 10

4. Marked on end of stud

   a. USCS -- the more slash marks, the stronger

   b. Metric - the higher the number, the stronger

   (NOTE: Small metric studs have a geometric shape stamped on the end to show strength -- a square is class 10.9, a cross is class 9.8 and a circle is class 8.8.)

I. Thread designations (FIG. 1-24)

1. USCS and metric show diameter first, pitch second, length last

2. USCS shows diameter in inches and number of threads per inch

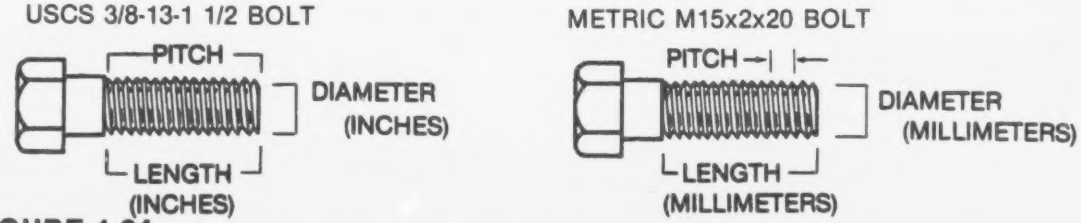

USCS 3/8-13-1 1/2 BOLT
PITCH
DIAMETER (INCHES)
LENGTH (INCHES)
METRIC M15x2x20 BOLT
PITCH
DIAMETER (MILLIMETERS)
LENGTH (MILLIMETERS)

FIGURE 1-24

3. Metric shows diameter in millimeters and distance between threads

VII. Prevailing-torque fasteners

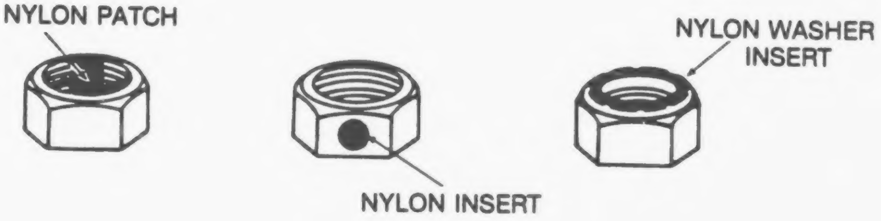
A. Have continuous resistance to turning. Torque needed to overcome this resistance is given.

B. No lock washer required

C. Methods of forming prevailing-torque fasteners

1. Nuts (FIG. 1-25)

FIGURE 1-25


NYLON PATCH
NYLON WASHER INSERT
NYLON INSERT

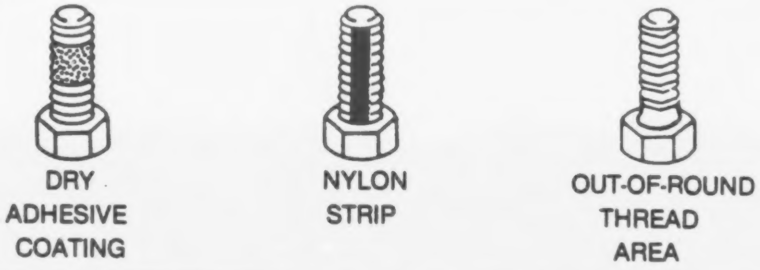
a. Nylon washer insert

b. Nylon insert

c. Nylon patch

2. Bolts (FIG. 1-26)

FIGURE 1-26


DRY ADHESIVE COATING
NYLON STRIP
OUT-OF-ROUND THREAD AREA

a. Dry adhesive coating

b. Nylon strip

754

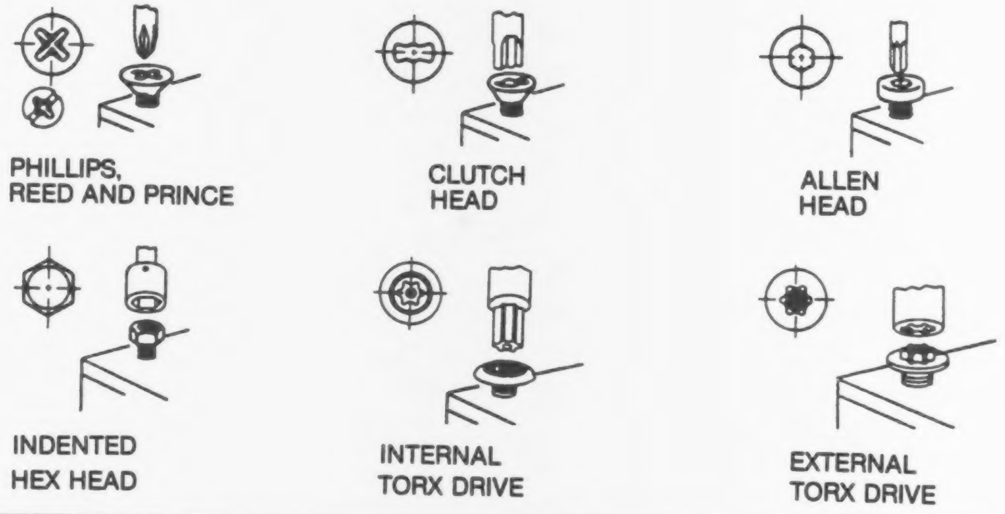
c. Out-of-round thread area

D. Do not reuse prevailing-torque fasteners if they are rusted or damaged in any way. If there is any doubt, throw it away.

E. If a prevailing-torque fastener is re-used, its torque must be checked. If the torque is less than designated it must be replaced.

VIII. Removal methods for bolts and nuts (FIG. 1-27)

FIGURE 1-27


PHILLIPS,
REED AND PRINCE
CLUTCH
HEAD
ALLEN
HEAD
INDENTED
HEX HEAD
INTERNAL
TORX DRIVE
EXTERNAL
TORX DRIVE

A. Removal methods can produce non-reusable fasteners

1. Generally any fastener which is not badly rusted or bent and has not sustained damage to threads may be reused. There are exceptions to this, however.
2. Do not reuse some prevailing torque fasteners, as previously indicated.
3. Do not reuse bolts, screws or nuts which have been heated for removal.

B. Antisieze compound

1. Whenever a steel bolt fits into aluminum threads, use antiseize compound--steel binds into aluminum.
2. Use when using a thread insert.

C. Methods of removing seized bolts and nuts

1. Penetrating oil
2. Using chisel and hammer or hacksaw

3. Using a nut-splitting tool

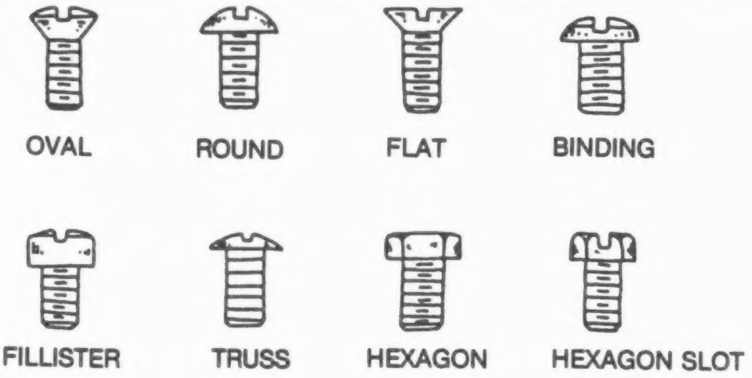
4. Using an oxyacetylene torch

(NOTE: Use caution when applying heat. Make certain that no gas lines are in the area, and that no brake lines or other components will be damaged.)

IX. Types of screws

A. Machine screws (FIG. 1-28)

FIGURE 1-28


OVAL
ROUND
FLAT
BINDING
FILLISTER
TRUSS
HEXAGON
HEXAGON SLOT

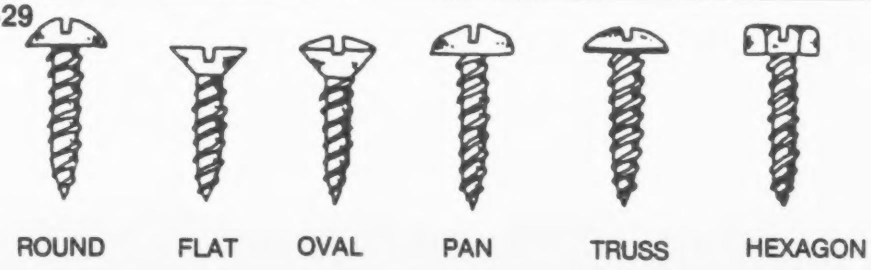
1. Variety of head styles

2. Variety of tools needed to tighten

3. Fine or coarse threads

B. Sheet metal screws (FIG. 1-29)

FIGURE 1-29


ROUND
FLAT
OVAL
PAN
TRUSS
HEXAGON

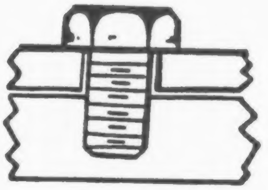
1. Variety of head styles

2. Any of a variety of tools needed to tighten

3. Extremely coarse threads for fastening into sheet metal

C. Cap screw (FIG. 1-30)

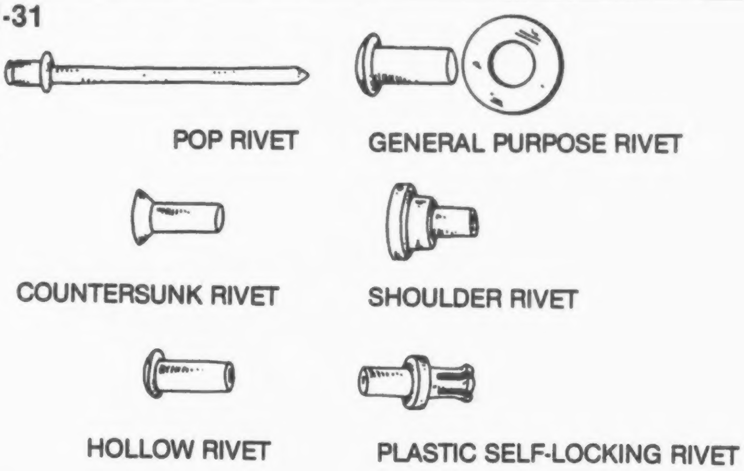
FIGURE 1-30



1. Hex head
2. May be either coarse thread (UNC) or fine thread (UNF)
3. Looks like a bolt, but uses no nut

X. Rivets (FIG. 1-31)

FIGURE 1-31


POP RIVET
GENERAL PURPOSE RIVET
COUNTERSUNK RIVET
SHOULDER RIVET
HOLLOW RIVET
PLASTIC SELF-LOCKING RIVET

A. Pop rivets
   1. Also called blind rivets -- Used with special pop-riveting tool
   2. Used where access to only one side of panel is possible

B. General-purpose rivet
   1. Usually driven with pneumatic hammer, with solid backing block held against opposite end.
   2. Used to fasten metal panels together

C. Countersunk rivet

    1. Like general purpose rivet, except for head
    2. Head is countersunk, providing a perfectly smooth surface.

D. Shoulder rivet

    1. Shoulder of rivet allows the attached component to move freely.
    2. Used in assembly of hinge mechanisms

E. Hollow rivet

    1. Has a hole through the center of shaft -- used with rivet-flaring tool to expand and anchor the rivet.
    2. Used only where little strength is required

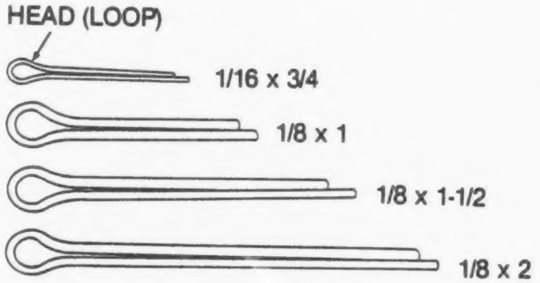
F. Plastic self-locking rivet

    1. Snapped into metal openings
    2. Provides an anchor point for various cables and linkages

XI. Miscellaneous fasteners

A. Cotter pins (FIG. 1-32)

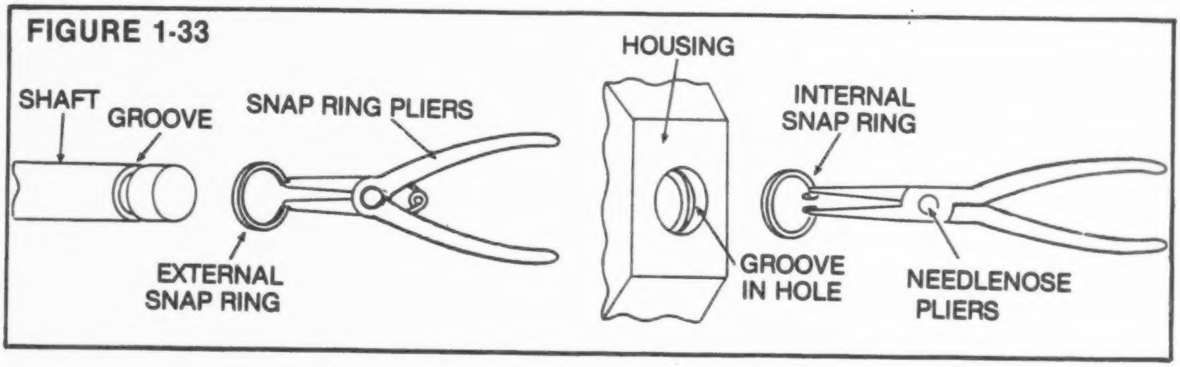
FIGURE 1-32



    1. Soft steel with loop for head
    2. Inserted into drilled hole: ends are then spread open.
    3. Used primarily with pins, or with castle nuts in places a nut is needed but is not to be tightened

B. Snap rings (FIG. 1-33)

FIGURE 1-33


SHAFT
GROOVE
SNAP RING PLIERS
EXTERNAL SNAP RING
HOUSING
INTERNAL SNAP RING
GROOVE IN HOLE
NEEDLENOSE PLIERS

1. Internal snap rings
2. External snap rings
3. Used on some shafts and on hose connections.

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MODULE: EXTERIOR AND INTERIOR TRIM

UNIT I: EXTERIOR TRIM

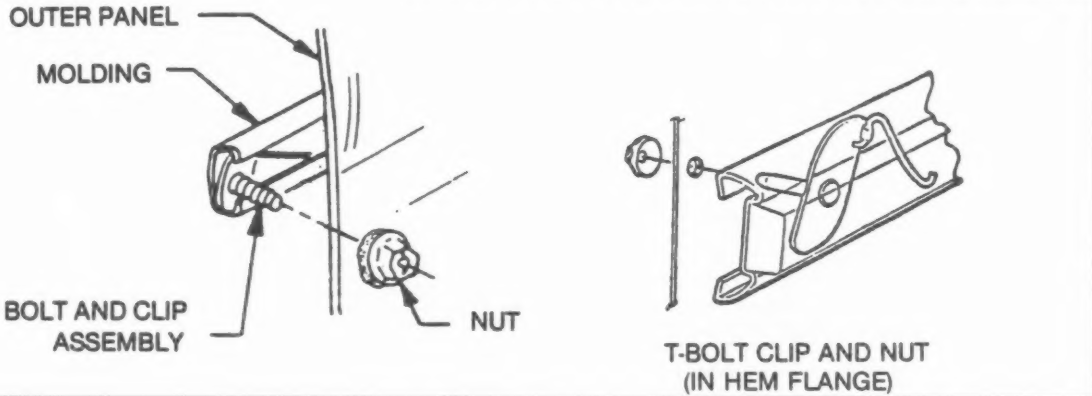
LESSON TWO: TRIM FASTENERS

I. Common trim fasteners

(NOTE: Each vehicle manufacturer uses a different variety of trim fasteners. Manufacturer's specifications will show location of trim piece and type of fastener used. There are five main methods of installing trim: screws, bolts, retaining clips, self-locking clips, and adhesive bonded. Trim fasteners should always be removed with a trim stick --a tool designed for removing trim.)

A. Held with screws and nuts (FIG. 2-1)

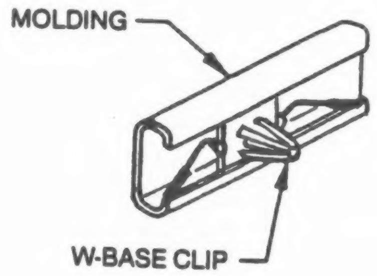
FIGURE 2-1 ***General Motors Corporation, 1987, used with permission***



1. Remove by locating retainer from the backside of the panel.
2. May be necessary to remove an interior panel or another feature, such as a mud guard

B. Held with W-base clips (FIG. 2-2)

FIGURE 2-2

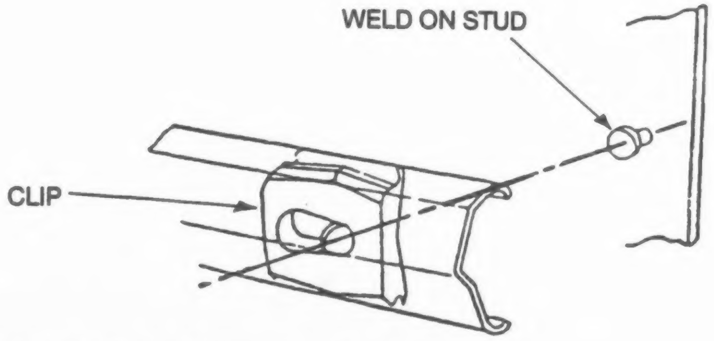


1. Remove with trim stick.
2. Apply slight outward pressure.

   *(**CAUTION:** W-base clips, as well as the moldings they hold and the painted surface of the vehicle, can be easily damaged during the removal of W-base clips.)*

C. Held with weld-on stud clip (FIG. 2-3)

FIGURE 2-3

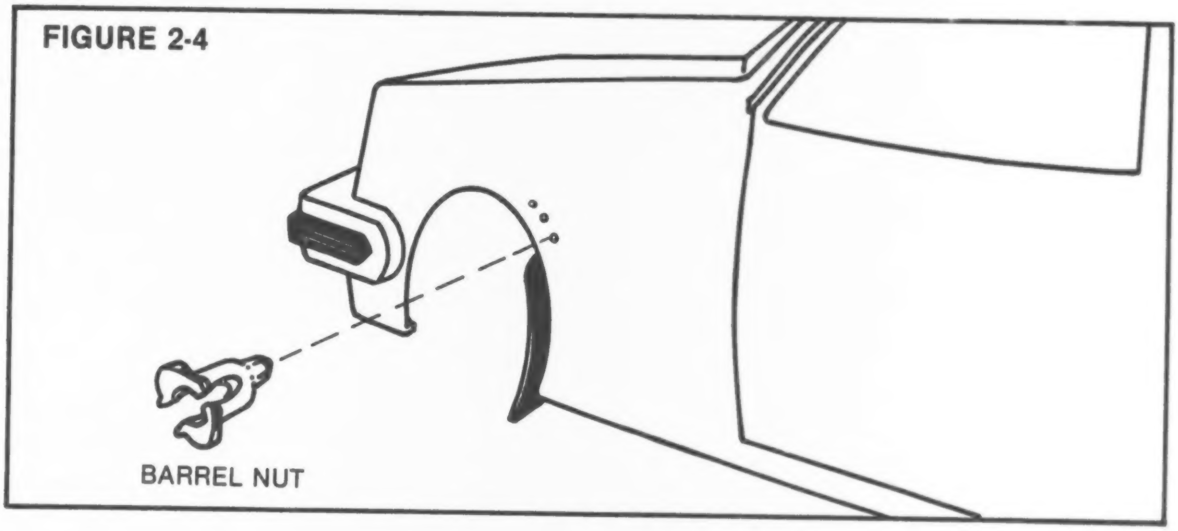


Adapted with permission of Mitchell International, Inc.

1. Remove with trim stick.
2. Apply slight outward pressure along edge of molding near retainers.

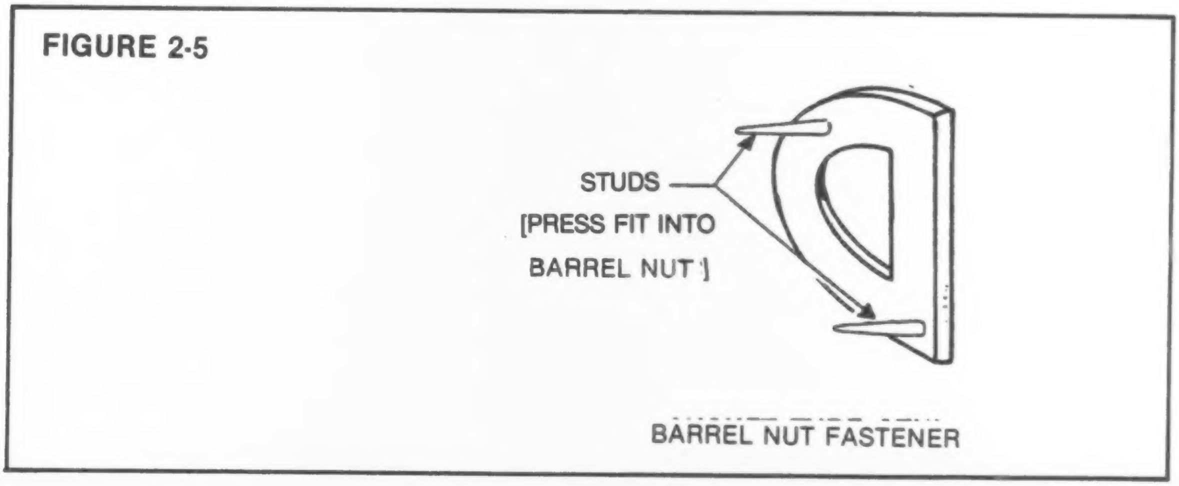
D. Held with barrel nut. (FIG. 2-4)

FIGURE 2-4



1. Remove with trim stick.
2. Apply slight outward pressure along edge of molding near barrel nut.
3. Used mostly for emblems and nameplates that have barrel nuts.
4. Barrel nut fasteners (FIG. 2-5)

FIGURE 2-5

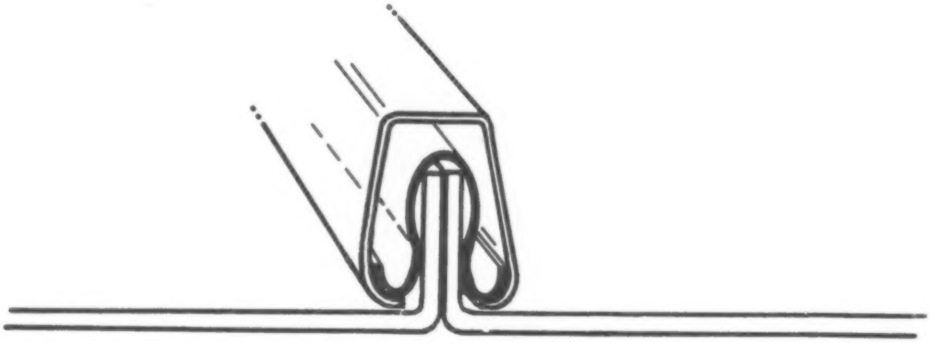

STUDS
[PRESS FIT INTO
BARREL NUT]
BARREL NUT FASTENER

a. Remove by tapping on stud behind panel. If back of panel is inaccessible use two trim sticks and apply slight outward pressure along edge of molding near retainers.

b. Nut is part of molding and if nut is broken, molding must be replaced.

E. Pinchweld clip (FIG. 2-6)

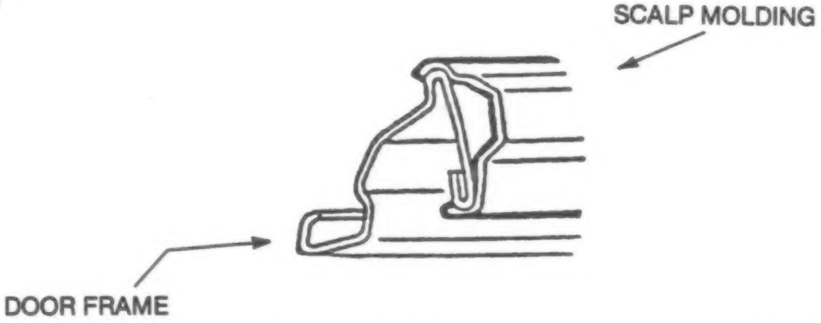
FIGURE 2-6



1. U-shaped clip which snaps over a pinchweld joint and retains the finishing molding or trim
2. Remove by placing a punch or screwdriver against lower edge and tapping on tool until the clip pops off.

F. Self-retaining (FIG. 2-7)

FIGURE 2-7



General Motors Corporation, 1987, used with permission

1. Remove by prying gently with appropriate tool.

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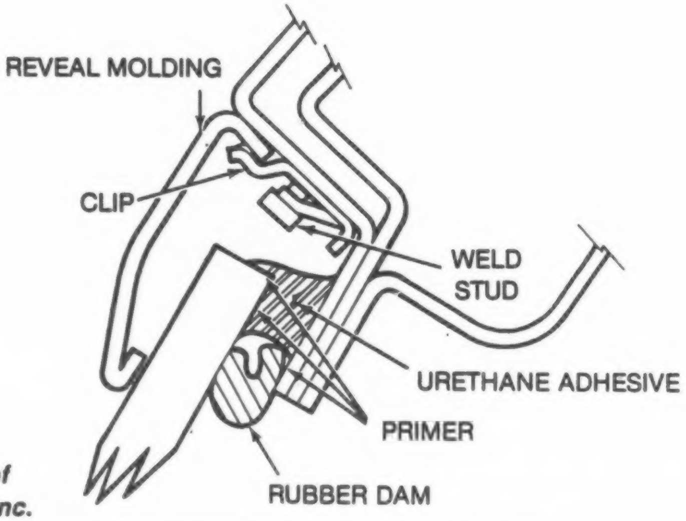
G. Reveal moldings (FIG. 2-8)

FIGURE 2-8


REVEAL MOLDING
CLIP
WELD STUD
URETHANE ADHESIVE
PRIMER
RUBBER DAM

Used with permission of Mitchell International, Inc.

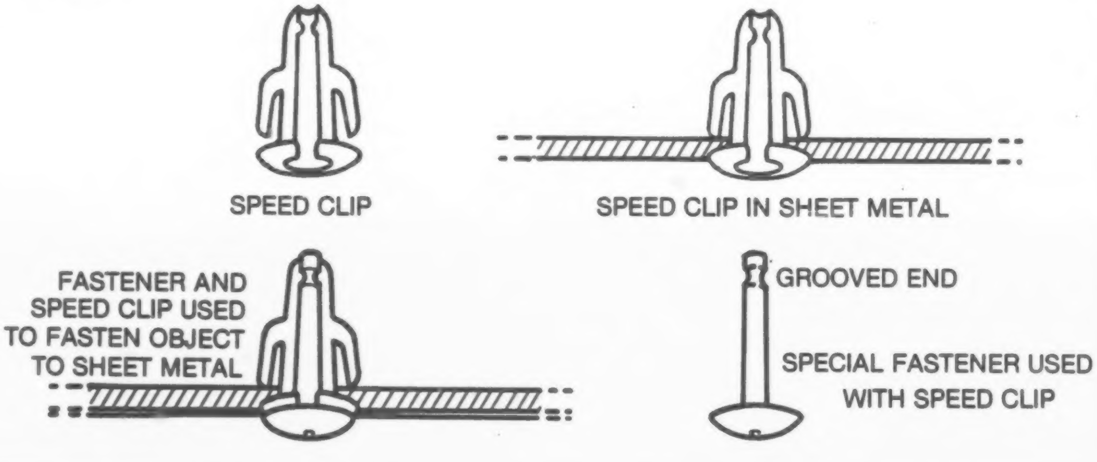
1. Used around stationary windows

2. A special reveal molding tool must be used to remove them.

   (NOTE: In replacing any moldings, sealing the area is important. Self-sealing screws, which have threads coated with sealant, are used. If replaced, they must be replaced with self-sealing screws. If clips are damaged and must be replaced, follow manufacturer's guidelines. Occasionally, it will be necessary to drill holes and install special replacement clips.)

H. Speed clips (FIG. 2-9)

FIGURE 2-9


SPEED CLIP
SPEED CLIP IN SHEET METAL
FASTENER AND SPEED CLIP USED TO FASTEN OBJECT TO SHEET METAL
GROOVED END
SPECIAL FASTENER USED WITH SPEED CLIP

A. Snapped into slightly oversized hole -- Spring action holds them in place

B. Varieties of studs used to fasten into speed clips

C. Used on trim assemblies that are pushed and snapped into place

IV. Adhesives

A. Attaching molding with adhesives is done in more and more places on vehicles.

B. Attached by using adhesive-backed taped

C. If trim must be removed, remove by prying on molding, starting at one end and working to the other end. Try prying with hands only. If necessary, use a trim stick.

D. If trim is loose on one end but does not have to be replaced, an adhesive bonding material may be applied to whichever side on the tape has come loose. Follow instructions for bonding material.

V. Replacing weld-on studs with stud gun

A. If weld-on studs are broken off, a weld-on stud gun may be used to replace them.

B. Safety when using stud gun

  a. Don't use on wet floors.

  b. Wear safety glasses.

  c. Don't use extension cords more than 30 feet in length or extension cords of less than 12-gauge wire.

C. Stud gun operation

  a. Grind paint from area to be welded.

  b. Insert appropriate stud into end of gun.

  c. Hold stud gun tight to metal.

  d. Don't pull trigger until gun is properly grounded.

  e. Don't hold trigger on for longer than 1.5 seconds when welding.

  f. Release trigger before releasing ground.

UNIT I

JOB SHEET #1, LESSON TWO

REMOVE AND REPLACE BELT MOLDING AND TRIM

Equipment

Vehicle
Vehicle service manual
Replacement molding
Replacement clips
Masking tape
Caulking
Common hand tools
Trim stick
Safety glasses

(NOTE: For evaluation purposes a screw- or clip-attached belt molding should be used for this job sheet.)

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
1. Put on safety glasses and mask adjacent finish with masking tape.	___	___	___	___
2. Examine molding or vehicle service manual to determine method of attachment.	___	___	___	___
3. Remove molding following service manual recommendations, using trim stick.	___	___	___	___
4. Examine attachment clips for damage and locate replacement clips if needed. If replacement clips must have holes drilled for them, perform Job Sheet #4.	___	___	___	___
5. Check new molding for proper fit, then snap molding into place or install screws or bolts, as applicable.	___	___	___	___
(If using screws or bolts, use self-sealing screws or apply caulking to bolts.)				
6. Check molding for snug fit and remove masking tape.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency O1 "Remove and replace belt molding and trim.)

UNIT I

JOB SHEET #2, LESSON TWO

REMOVE AND REPLACE DRIPRAIL SCALP MOLDING AND TRIM

Equipment

Vehicle
Vehicle service manual
Replacement molding
Masking tape
Caulking
Common hand tools
Safety glasses

Procedure:	Evaluation: 3	2	1	N
1. Put on safety glasses and mask adjacent finish with masking tape.	___	___	___	___
2. Examine molding or vehicle service manual to determine method of attachment.	___	___	___	___
3. Remove molding following service manual recommendations. Remove screws, if screws are used, then use a screwdriver with the blade wrapped with masking tape to pry off molding. *(NOTE: If molding has no retaining screws or clips a sealant should be applied according to manufacturer's recommendations.)*	___	___	___	___
4. Check new molding for proper fit, then hook molding over top edge and rotate downward. Snap over bottom edge using hand pressure only.	___	___	___	___
5. Replace screws, if applicable, using self-sealing screws or caulking.	___	___	___	___
6. Check molding for snug fit and remove masking tape.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency O2 "Remove and replace driprail scalp molding and trim.")

UNIT I

JOB SHEET #3, LESSON TWO

REMOVE AND REPLACE GLUE-ON MOLDING AND TRIM

Equipment:

Vehicle
Vehicle service manual
Replacement molding
Masking tape
Common hand tools
Bucket of mild detergent solution
Oil-free naphtha or denatured alcohol
Clean cloths
Heat lamp or heat gun
Safety glasses

(NOTE: For evaluation purposes, a molding attached with adhesive foam or butyl tape should be used for this job sheet.)

Procedure:	**Evaluation:** 3	2	1	N
1. Put on safety glasses and examine service manual for recommended procedure. Then place masking tape along bottom edge of molding for replacement positioning guideline.	___	___	___	___
2. Remove molding following service manual recommendations, starting at one end and using only hand pressure, if possible.	___	___	___	___
3. Wash off old adhesive using mild detergent and water. Wipe clean with a dry cloth.	___	___	___	___
4. Position molding on strip and apply short strips of masking tape over molding every 6 to 8 inches to hold into position.	___	___	___	___
5. Unstick top edges of masking tape to allow molding to drop down, exposing bonding area, while making sure bottom edge of tape holds molding.	___	___	___	___

(NOTE: Check surface temperature of metal. Most adhesives will work within the range of 65°F. to 95°F. If panel is too cold, heat with heat lamp or heat gun.)

Procedure:	**Evaluation:** 3	2	1	N
6. Apply adhesive according to adhesive manufacturer's recommendations.	___	___	___	___
7. Pull molding up and check for proper alignment and press molding into position and hold according to adhesive manufacturer's recommendations.	___	___	___	___
(NOTE: Some adhesives may be held in position firmly by hand pressure for 30 seconds. Others must be held for 15 minutes. In the latter case, use masking tape to secure molding firmly while adhesive cures.)				
8. Clean excess adhesive or tape residue with naphtha or denatured alcohol.	___	___	___	___
(NOTE: Do not expose repaired molding to rain or do not wash car for at least 24 hours.)				
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency O3 "Remove and install glue-on molding and trim.")

UNIT I

JOB SHEET #4, LESSON TWO

LOCATE AND DRILL HOLES FOR MOLDING AND TRIM

Equipment

Vehicle
Vehicle service manual
Replacement molding
Replacement clips
Masking tape
Caulking
Common hand tools including hand drill and proper bit
Safety glasses

Procedure:		**Evaluation:** 3	2	1	N
1.	Put on safety glasses and remove old molding following service manual recommendations, using masking tape on adjacent areas of panel.	___	___	___	___
2.	Examine molding or replacement molding and vehicle service manual to determine location of holes to be drilled.	___	___	___	___
	(For weld-stud replacement, location should be 1/4" from weld-stud.)				
3.	Center punch-spot to be drilled and drill hole of appropriate size for fastener.	___	___	___	___
4.	Install trim fasteners into hole, if applicable, using self-sealing screws or body caulking.	___	___	___	___
5.	Check molding for proper alignment with fasteners, then snap molding into place or install screws or bolts, as applicable.	___	___	___	___
6.	Check molding fit and remove masking tape.	___	___	___	___
	Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency O4 "Locate and drill holes for molding and trim.")

UNIT I

JOB SHEET #5, LESSON TWO

USE WELD-ON STUD GUN TO INSTALL MOLDING

Equipment

Vehicle
Vehicle service manual
Weld-on stud gun
Replacement molding
Replacement clips
Masking tape
Anti-corrosion paste
Common hand tools
Safety glasses

(NOTE: In the case of weld-stud moldings, broken weld studs can be replaced with the weld-on stud gun, rather than replacing with an alternate replacement clip.)

Procedure:	**Evaluation:** 3	2	1	N
1. Put on safety glasses and remove old molding following service manual recommendations, using masking tape to protect adjacent areas of panel.	___	___	___	___
2. Examine panel to determine location of weld-on stud.	___	___	___	___
3. Select stud of appropriate size and prepare surface by following stud-gun manufacturer's recommendations.	___	___	___	___
4. Position stud and stud gun and weld following stud gun manufacturer's recommendations.	___	___	___	___
5. Position fastener on stud to check fit and install fastener.	___	___	___	___
6. Install molding as recommended.	___	___	___	___
7. Check molding fit and remove masking tape.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency O5 "Use weld-on stud gun to install molding.")

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT I: EXTERIOR TRIM

UNIT TEST

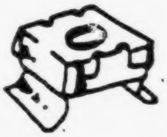
PART I–BOLTS AND NUTS

I. Match each term in the left column with the most closely associated term or illustration in the right column.

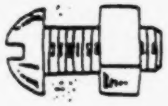
_____1. Coarse threads
_____2. Fine threads
_____3. Hex head
_____4. Right-hand threads
_____5. Speed nut
_____6. Carriage bolt
_____7. Machine bolt
_____8. Stove bolt
_____9. US bolt
_____10. Metric bolt
_____11. Stud
_____12. Acorn nut
_____13. Retainer nut

A. Turn clockwise
B. Round head, square shank
C. Any six-sided
D. UNC or USS
E. UNF or SAE
AB. Five slash marks
AC. No head
AD. 4.8
AE. Domed head
BC. Used where no strength is required

BD.



BE.



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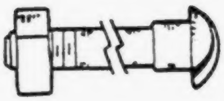
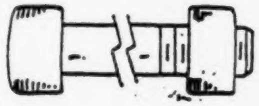


CE.



II. Match each term in the left column with the most closely associated illustration in the right column.

_____14. Finishing washer

_____15. Lock washer

_____16. Fender washer

_____17. Body washer

_____18. Prevailing-torque nut

_____19. Prevailing-torque bolt

_____20. Wing nut

_____21. Castle nut

_____22. Palnut

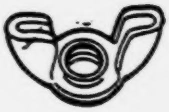
_____23. Flanged hex nut

_____24. Speed nut

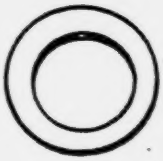
_____25. USCS bolt

_____26. Metric bolt

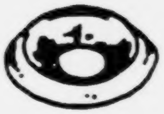
A.



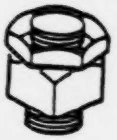
B.



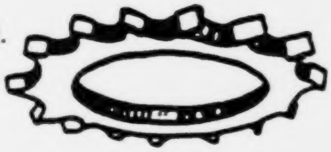
C.



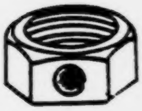
D.



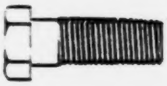
E.



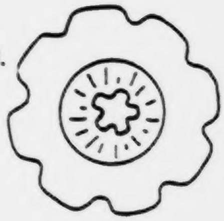
AB.



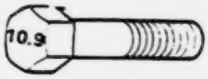
AC.



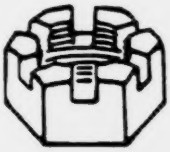
AD.



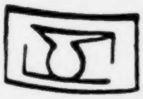
AE.



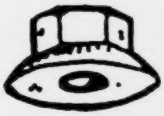
BC.



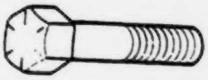
BD.



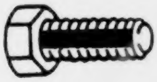
BE.



CD.



CE.



III. Select the best answer from the choices listed.

_____27. For a USCS bolt, which of the following marks on the head of the bolt would indicate the greater strength: (a) no marks, (b) 9.8, (c) three slash marks, (d) 10.9, (e) five slash marks.

_____28. For a metric nut, which of the following marks on the rim would indicate the greater strength: (a) three dots, (b) five slash marks, (c) six dots, (d) 9, (e) 10.

_____29. For a USCS bolt with 13 threads per inch, one-half inch in diameter and two inches long, which would be the proper thread designation: (a) 1/2-2 X 13, (b) 13-2 X 1/2, (c) 1/2-13 X 2, (d) 13 X 2-1/2, (e) 2-13 X 1/2.

_____30. For a metric bolt with 1.75 millimeters between threads, 11 millimeters in diameter and 30 millimeters long, what would be the proper thread designation: (a) M1.75-11 X 30, (b) M11-1.75 X 30, (c) M30-1.75 X 11, (d) M11-30 X 1.75, (e) M30-11 X 1.75.

_____31. The pitch of a USCS bolt refers to the bolt's: (a) thread angle, (b) threads per inch, (c) thread diameter, (d) thread series, (e) thread height.

_____32. Which of the following is NOT a characteristic of a stud: (a) may use a nut, (b) usually attaches to a casting, (c) usually has different threads on each end, (d) has no head, (e) used to fasten body panels.

_____33. The thing which most distinguishes a bolt from a screw is that a bolt: (a) has finer threads, (b) uses a nut, (c) takes a wrench, (d) uses a washer, (e) has a flat head.

(NOTE: Completion of this portion of the unit test is the evaluation for Competency N1 "Identify types of bolts and nuts, US and metric." Of the 33 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, and _____ correct or below, the student should retake this portion of the test.)

PART II—RIVETS

I. **Match each term in the left column with the proper illustration in the right column. The choices in the right column may be used more than once.**

_____34. Pop rivet

_____35. Countersunk rivet

_____36. General-purpose rivet

_____37. Shoulder rivet

_____38. Hollow rivet

_____39. Plastic self-locking rivet

_____40. Provides smooth surface

_____41. Allows component to move

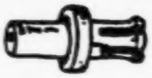
_____42. Driven with pneumatic hammer

_____43. Blind rivet

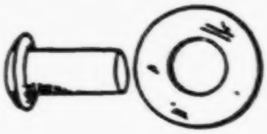
_____44. Snapped into place

_____45. Used with flaring tool

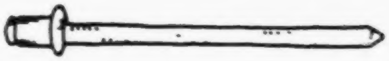
A.



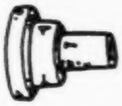
B.



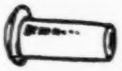
C.



D.



E.



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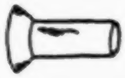


(NOTE: Completion of this portion of the unit test is the evaluation for competency N2 "Identify types of rivets." Of the 12 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, and _____ correct or below, the student should retake this portion of the test.)

PART III–SCREWS

I. Match each term in the left column with the proper illustration in the right column.

_____46. Oval machine screw

_____47. Hexagon slot machine screw

_____48. Fillister machine screw

_____49. Flat machine screw

_____50. Round machine screw

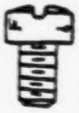
_____51. Cap screw

_____52. Oval sheet-metal screw

_____53. Flat sheet-metal screw

_____54. Hexagon sheet-metal screw

_____55. Round sheet-metal screw

A.


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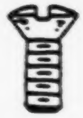

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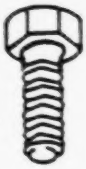

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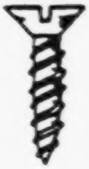

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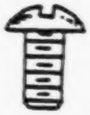

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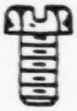

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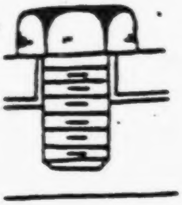

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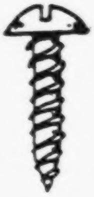

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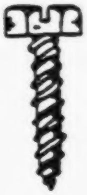
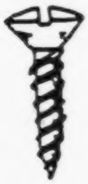
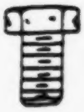
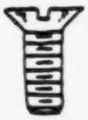


BC.


BD.


BE.


(NOTE: Completion of this portion of the unit test is the evaluation for Competency N3 "Identify types of screws." Of the 10 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this portion of the test.)

PART IV—CLIPS

I. Match each of the terms in the left column with the correct illustration in the right column. The illustrations in the right column may be used more than once.)

_____56. Held with nut

_____57. Barrel nut

_____58. Barrel nut fastener

_____59. Weld-on stud clip

_____60. Pinchweld clip

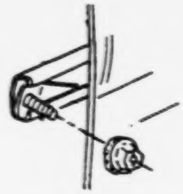
_____61. W-base clip

_____62. Self-retaining

_____63. Reveal molding clip

_____64. Speed clip

A.



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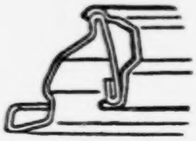

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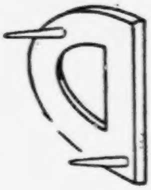

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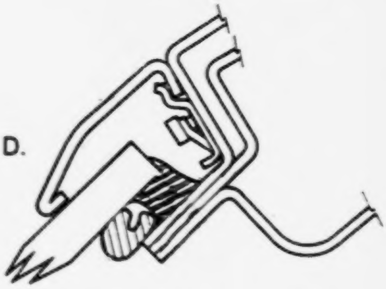

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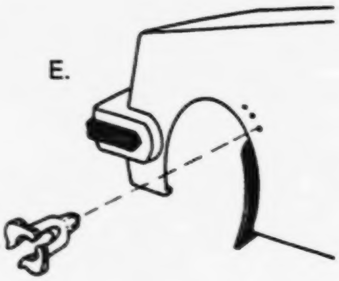

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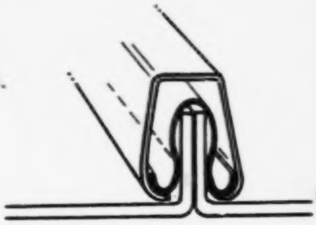

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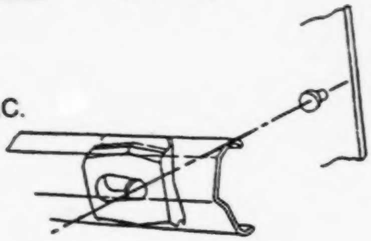

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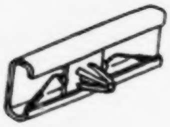
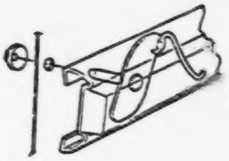


AE.



(NOTE: Completion of this portion of the unit test is the evaluation for Competency N4 "Identify types of clips." Of the 9 questions, _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, the student should retake this portion fo the test.)

ANSWERS TO UNIT I TEST

PART I.

1. D
2. E
3. C
4. A
5. BC
6. CD
7. CE
8. BE
9. AB
10. AD
11. AC
12. AE
13. BD

14. C
15. E
16. B
17. AD
18. AB
19. BE
20. A
21. BC
22. D
23. CE
24. BD
25. CE
26. AE

27. e
28. e
29. c
30. b
31. b
32. e
33. b

PART II.

34. C
35. AB
36. B
37. D
38. E
39. A
40. AB
41. D
42. B
43. C
44. A
45. E

PART III.

46. B
47. AB
48. A
49. BE
50. E
51. AC
52. BC
53. D
54. AE
55. AD

PART IV.

56. AE
57. E
58. C
59. AC
60. AB
61. AD
62. B
63. D
64. A

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT II: VINYL TOPS AND DECALS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify and service vinyl tops and decals. Mastery will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Identify vinyl top construction and replacement (Competencies P1-P3, Unit II test)

II. Identify decal replacement (Competency P4, no test items)

III. Demonstrate the ability to:

   a. Remove and replace vinyl tops (Competency P1, Job Sheet #2)

   b. Repair vinyl tops (Competency P2, Job Sheet #3)

   c. Refinish vinyl tops (Competency P3, Job Sheet #3)

   d. Remove and replace decals and stripes (Competency P4, Job Sheet #4)

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT II: VINYL TOPS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. References

   1. Lesson 1: Vinyl Tops and Decals

      a. Information outline

      b. Transparency masters

         TM#1: Vinyl roof outside cover
         TM#2: Vinyl roof repair

      c. Job sheets

         JS#1: Mix and apply adhesive
         JS#2: Remove and replace vinyl top
         JS#3: Repair and refinish vinyl tops
         JS#4: Remove and replace decals and stripes

D. Unit test

E. Answers to unit test

REFERENCES USED IN WRITING THIS UNIT

1. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

2. Czapskie, George S., et. al. *Auto Body Repair.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1977.

3. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL. 1984.

4. General Motors Corporation. *1987 Body Service Manual (Buick, Oldsmobile, Cadillac).* General Motors Corporation. 1986.

5. Mitchell Information Services, Inc. *Body and Mechanical Parts Service & Repair, Domestic Cars, 1981-85.* Mitchell Information Services. San Diego, CA. 1985.

6. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

7. Walters, Terry, and Walker, Susan. *Automotive Body Repairer.* Curriculum & Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education. Stillwater, OK. 1986.

MODULE: EXTERIOR AND INTERIORTRIM

UNIT II: VINYL TOPS

LESSON ONE: VINYL TOPS AND DECALS

I. **Principles of vinyl tops**

A. Three basic styles of vinyl tops

1. Full top
2. Landau -- half vinyl
3. With sun roof

B. Three basic types of vinyl top applications

1. Vinyl-coated fabric -- Glued directly to roof panel.
2. Vinyl-coated fabric with plastic cap -- Plastic cap glued to roof panel and vinyl top then glued to plastic cap.
3. Vinyl-coated fabric with foam pad -- Foam pad glued to roof and vinyl top then glued to foam pad.

(NOTE: Another, less common type of "vinyl top" is one in which a textured paint is sprayed onto the roof panel, giving it the appearance of a vinyl top.)

C. Methods of holding vinyl tops in place

1. In areas extending into the windshield and back window openings, use bonding adhesive, plus one or more of the following:
    a. Clips installed over weld-on studs
    b. Drive nails
    c. Reveal molding and finishing lace
2. In areas not extending into window openings, on which there are no reveal moldings, use one or more of the following:
    a. Bonding adhesive
    b. Tabbed retainers
    c. Finishing lace
3. In areas where the top extends around drip moldings or folds around roof-panel flange, one or more of the following:
    a. Adhesive and drip-scalp moldings
    b. Weatherstrip retainers

  c. Finish moldings

D. Bonding adhesive

  1. In using bonding adhesive, a heat gun is applied to the material. The maximum heat application to vinyl is 200° F. More than 200° F. may cause the vinyl to either lose its grain or blister.

  2. Refer to manufacturer's recommendation for type of bonding adhesive to use.

  3. Bonding adhesive is mixed like paint and applied with a spray gun and compressed air.

E. Trim items removed in vinyl top removal procedures:

  1. Items found in most applications and removed

    a. Front and back glass reveal moldings

    b. Drip-scalp moldings, weatherstrip retainers or finish moldings

    c. Rear-quarter-belt reveal moldings and rear-end-belt reveal moldings

  2. Additional items which may have to be removed, if present

    a. Roof-cover retainer-to-rear-body lock pillar

    b. Emblems, name plates or decorative assemblies

    c. Quarter window reveal moldings or roof-panel moldings

    d. Louvers, louver quarter stationary windows, sliding sun-roof panel or vista-vent glass and weatherstrips

    e. Reveal molding clips across top and sides of stationary glass openings, and occasionally reveal moldings clips across the bottom of stationary glass

    f. Vinyl on the center post fastened with rivets, in which rivets must be drilled out

F. Repair methods

  1. The introduction of liquid vinyl has meant that many types of vinyl top damage can be repaired.

  2. Properties of liquid vinyl

    a. Paste which can fill small holes or torn sections

    b. Cures with application of heat

    c. Bonds to original vinyl

d. Comes in a variety of colors and can be mixed like paint, or can be painted over.

e. Can be given same grain as vinyl to be repaired using a die made from the same vinyl or similar vinyl. Die is pressed against liquid vinyl as it cures. Grain pattern hardens into repaired area.

3. Additional materials for vinyl repair

   a. Vinyl cleaner solvent

   b. Vinyl repair paint

   c. Razor knife

   d. Pallet knife

4. Basic repair method

   a. Apply liquid vinyl.

   b. Use pallet knife to smooth liquid vinyl.

   c. Use heat gun to cure the vinyl, applying die before completely cured.

   d. Paint if necessary.

G. Removing wrinkles

1. Wrinkles may occur but may smooth out after several days' exposure to sunlight.

2. If they remain, first try a household iron, at medium heat, pressed over a dampened shop cloth.

3. If iron method fails, use the following procedure:

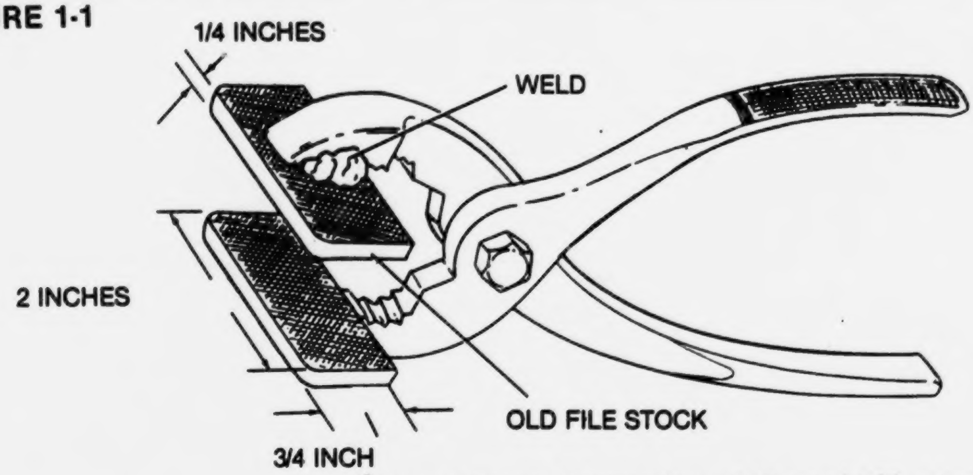
   a. Remove moldings near wrinkled area, apply heat from heat gun and pull on edge of fabric

   b. When fabric comes loose, brush on adhesive.

   c. When adhesive becomes tacky, press cover and slick down.

4. Specially built pliers to stretch vinyl tops (FIG. 1-1)

FIGURE 1-1



General Motors Corporation, 1987, used with permission

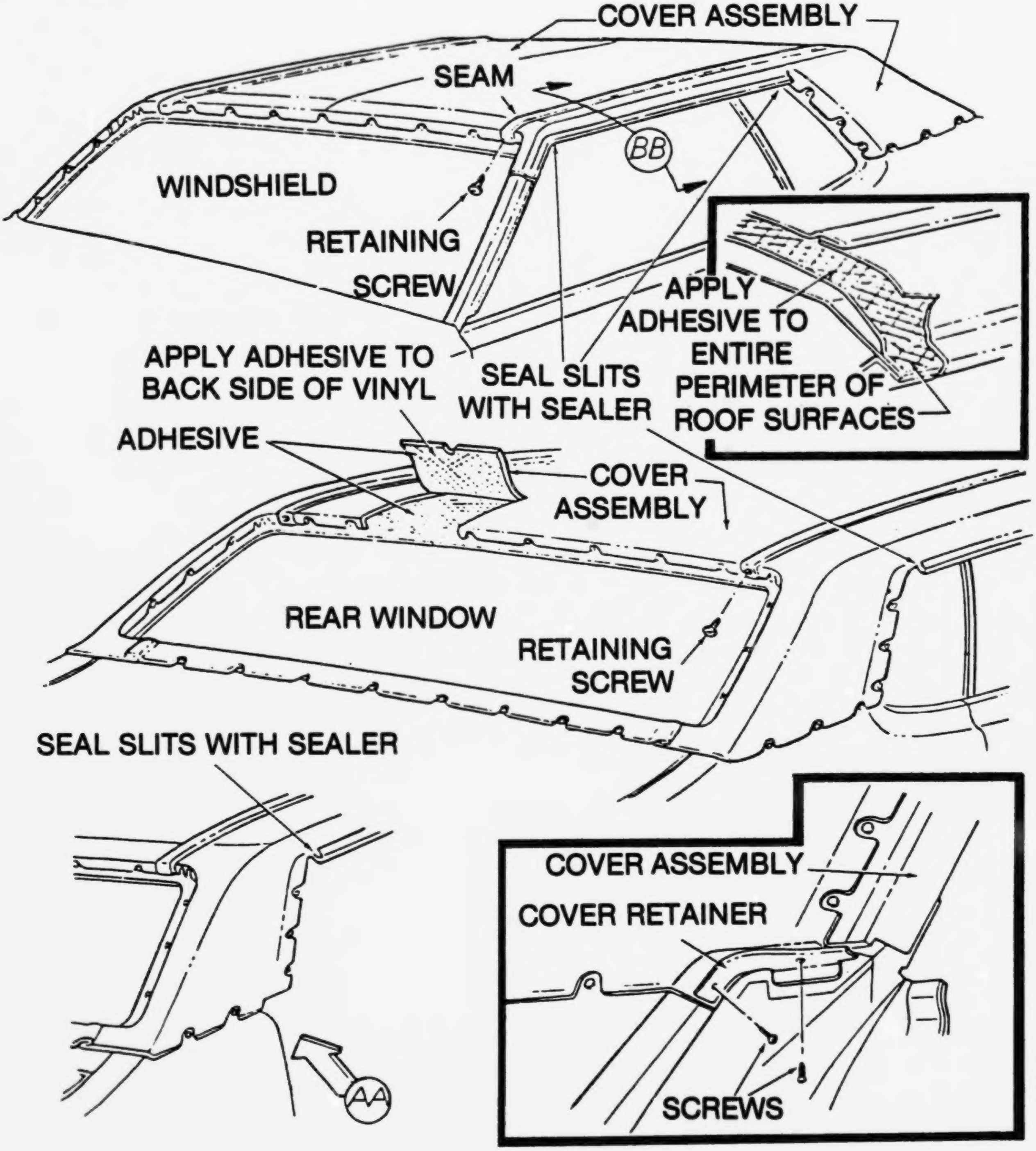
II. Decals

A. Decals come in a variety of sizes, including very large transfers.

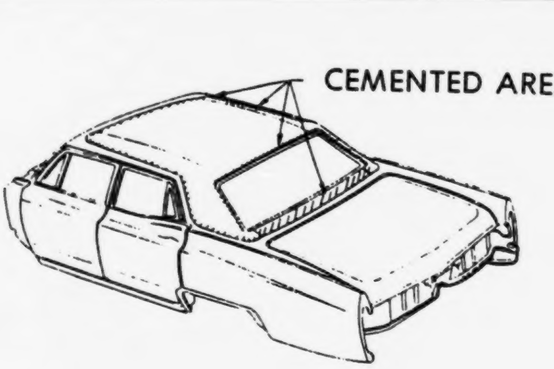
B. Decals may be repaired by touch-up painting in the same way small nicks in paint can be repaired.

C. Small air bubbles may be repaired by using a sharp needle to puncture the bubble. A squeegee is then used to force out the air. A heat lamp may be necessary to soften the material and reactivate the adhesive on the back.

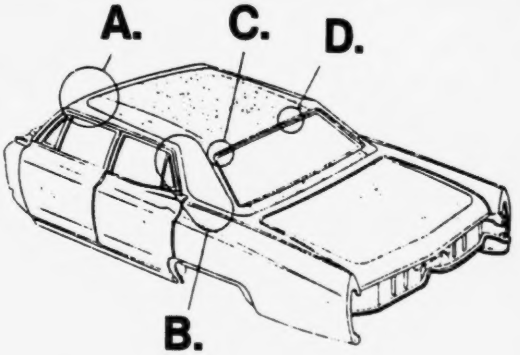
Vinyl Roof Outside Cover

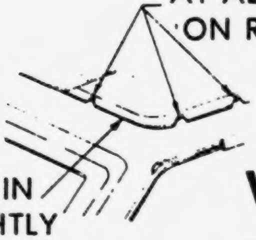

COVER ASSEMBLY
SEAM
BB
WINDSHIELD
RETAINING SCREW
APPLY ADHESIVE TO ENTIRE PERIMETER OF ROOF SURFACES
APPLY ADHESIVE TO BACK SIDE OF VINYL
SEAL SLITS WITH SEALER
ADHESIVE
COVER ASSEMBLY
REAR WINDOW
RETAINING SCREW
SEAL SLITS WITH SEALER
AA
COVER ASSEMBLY
COVER RETAINER
SCREWS

Vinyl Roof Repair



CEMENTED AREA

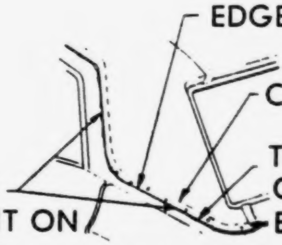




CUT RELIEF NOTCHES AT ALL WELD-ON STUDS ON ROOF PANEL

TRIM COVER IN A LINE SLIGHTLY OUTBOARD OF WELD-ON STUDS

VIEW A



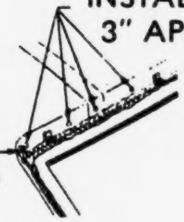
EDGE OF PAD

CEMENTED AREA

TRIMMED EDGE OF COVER (SLIGHTLY BELOW WELD-ON STUDS)

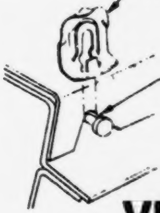
APPLY FILM COAT OF AUTOMOTIVE SEALANT ON EDGES OF COVER

VIEW B



INSTALL DRIVE NAILS APPROX 3" APART AND AT CORNERS

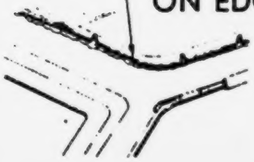
CUT RELIEF NOTCHES IN CORNERS



REVEAL MOLDING CLIP

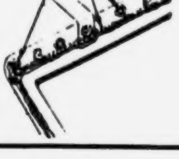
RELIEF NOTCH AT WELD ON STUDS IN BACK WINDOW OPENING

VIEW D



APPLY FILM COAT OF AUTOMOTIVE SEALANT ON EDGES OF COVER

VIEW C



APPLY FILM COAT OF AUTOMOTIVE SEALANT AT ALL EDGES OF COVER IN BACK WINDOW OPENING AND TO ALL DRIVE NAIL HEADS

UNIT II

JOB SHEET #1, LESSON ONE

MIX AND APPLY ADHESIVE

Equipment:

Paint gun and compressor
Vinyl replacement top
Vehicle
Masking tape
Hand tools for removal of old vinyl top
Safety glasses and breathing apparatus

(NOTE: Room temperature should be approximately 72° F. for this procedure, with all materials at room temperature.)

Procedure: **Evaluation:**

3 2 1 N

1. After old vinyl top is removed, pour adhesive into paint gun. Cut without thinning and set the air line pressure at 50 psi. ___ ___ ___ ___

2. Holding gun approximately 18" from work area, apply even coat of adhesive to roof cover. ___ ___ ___ ___

3. Spray half of roof panel and edges of any moldings or other areas necessary. ___ ___ ___ ___

4. After application, clean paint gun and cup thoroughly with adhesive solvent. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average will become a part of Job Sheet #2 and is not a competency evaluation.)

UNIT II

JOB SHEET #2, LESSON ONE

REMOVE AND REPLACE VINYL TOP

Equipment

Paint gun and compressor
Vinyl replacement top
Vehicle
Masking tape
Hand tools for removal of old vinyl top
Safety glasses and breathing apparatus
Vinyl cleaner solvent
Vinyl repair paint
Razor knife and pallet knife

Procedure:	**Evaluation:** 3	2	1	N
1. Put on eye protection and remove moldings and emblems as required, according to appropriate methods or job sheets in Unit I, this module.	___	___	___	___
2. Remove molding clips as required and drive nails.	___	___	___	___
(**CAUTION:** *Always tape edges of glass areas to prevent damage from removing moldings.)*				
3. Remove fabric cover, applying heat with heat gun, 18 inches from surface, to a maximum of 200° F.	___	___	___	___
4. Repair or replace roof pad as needed, if roof pad is present.	___	___	___	___
5. Mask car well down over sides to prepare for top replacement and remove the old adhesive. It is not necessary to remove all of the old adhesive -- only enough to insure no wrinkles or bumps.	___	___	___	___
6. Determine center line of roof panel and mark on front and back glass.	___	___	___	___
7. Determine centerline of new cover, fold in center and mark. Lay cover on top of car and center front-to-rear.	___	___	___	___
8. Lay cover upside down on clean surface and apply adhesive by performing Job Sheet #1.	___	___	___	___

Procedure:	**Evaluation:** 3	2	1	N
9. Lay cover on roof panel, folded in half. With two people working, lay down and smooth cover using heat gun and roller.	___	___	___	___
10. Lay cover on other side of roof panel.	___	___	___	___
11. Trim edges, cutting relief notches at corners, trimming belt line below studs and trimming around clip studs.	___	___	___	___
12. Replace drive nails and seal edges with silicone sealer.	___	___	___	___
13. Replace retainer clips and moldings.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation Competency P1 "Remove and replace vinyl tops.")

UNIT II

JOB SHEET #3, LESSON ONE

REPAIR AND REFINISH VINYL TOPS

Equipment:

Paint gun and compressor
Vinyl patching compound
Vehicle
Masking tape and paper
Safety glasses and breathing apparatus
Vinyl cleaner solvent
Vinyl repair paint
Razor knife
Pallet knife
Heat gun
Graining paper or die

Procedure:	**Evaluation:** 3	2	1	N
1. Clean area to be repaired with mild detergent and dry.	___	___	___	___
2. Trim out damaged area, leaving only good material.	___	___	___	___
3. Apply liquid vinyl to area and smooth with pallet knife.	___	___	___	___
(NOTE: If area to be repaired is deep, several coats may have to be applied and cured to build up area.)				
4. Apply heat from heat gun to cure liquid vinyl.	___	___	___	___
5. When vinyl is almost hard, apply die or graining paper to impart grain.	___	___	___	___
6. After vinyl is cured, mask adjacent areas of roof and cover or mask rest of vehicle as applicable. Mix matching paint and paint repaired area.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency P2 "Repair vinyl tops" and competency P3 "Refinish vinyl tops.")

UNIT II

JOB SHEET #4, LESSON ONE

REMOVE AND REPLACE DECALS AND STRIPES

Equipment:

Vehicle and vehicle service manual
Replacement decal
Masking tape and masking paper
Safety glasses
Woodgrain remover spray
Squeegee
Straightedge
Grease pencil

(NOTE: The procedure outlined below is for replacing decals and stripes on acrylic enamel finishes where no wetting solution is required. Removing woodgrain on acrylic enamel finishes may also be substituted, with slight modifications to the procedure. For large decal transfers, such as those covering the hoods of some vehicles, special considerations apply. Always consult vehicle service manual for specific steps of procedure. Large decal transfers are expensive and are easily damaged if not handled properly. On finishes other than acrylic enamel, wood-grain remover spray cannot be used. Consult vehicle manufacturer's service manual for removal procedure.)

Procedure: **Evaluation:**
3 2 1 N

1. Clean old decal and adjacent areas thoroughly, then dry surface. ___ ___ ___ ___

   (NOTE: For woodgrain overlays, remove reveal moldings, if present.)

2. Put on safety glasses and mask areas adjacent to decal with masking tape and paper, being very careful to align masking material properly. ___ ___ ___ ___

   (NOTE: The temperature of the vehicle surface should be between 65°F. to 95°F. Apply heat lamps or heat gun if needed.)

3. Spray decal thoroughly and evenly with woodgrain remover, first entirely with a side-to-side motion, then entirely with an up-and-down motion. ___ ___ ___ ___

   (**CAUTION:** *Use woodgrain remover only in well-ventilated area and avoid breathing fumes, which are toxic. Follow label directions on remover.)*

Procedure:

Evaluation:
3 2 1 N

4. Wait 20 minutes for remover to work, then start peeling decal off. Starting from a flange area. Peel decal lengthwise, using a squeegee if needed. ___ ___ ___ ___

5. Scrape woodgrain remover from panel, then spray panel with adhesive remover. Apply slowly and evenly over panel. ___ ___ ___ ___

6. Wait five minutes for remover to work, then squeegee adhesive residue away. If needed reapply remover, wait two minutes and squeegee again. ___ ___ ___ ___

7. Remove masking tape and paper and wash panel with general-purpose adhesive cleaner. ___ ___ ___ ___

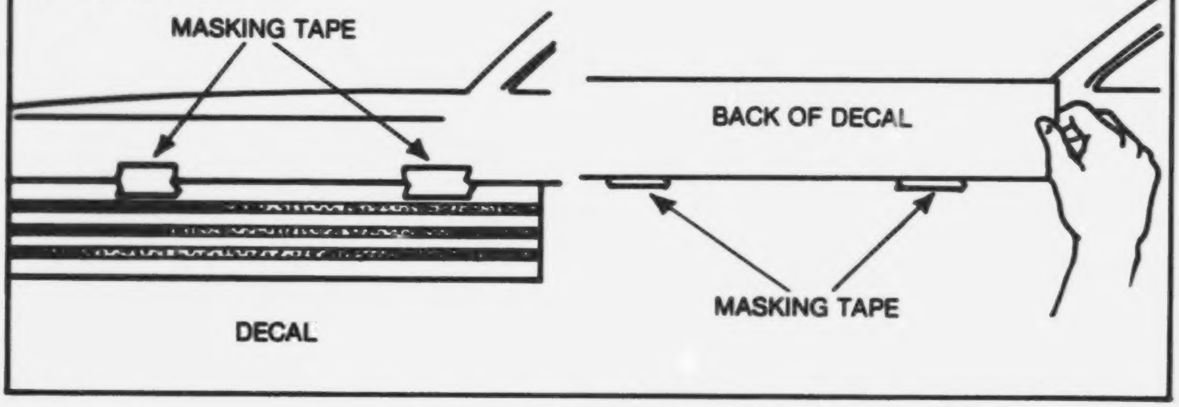
   (NOTE: For woodgrain transfers, the area must be sanded with 360 or 400 grit sandpaper and a wetting solution is used. Consult service manual for procedure.)

8. Without removing backing paper, position decal on the panel surface and mark position with a grease pencil and straightedge. ___ ___ ___ ___

9. Leaving one-half-inch overlap for wrapping around door panel or other creases, cut decal to proper length. ___ ___ ___ ___

10. Position decal, paper still attached, in place and secure the decal with small strips of masking tape, then lift decal using masking tape as hinges. ___ ___ ___ ___

FIGURE 1-2



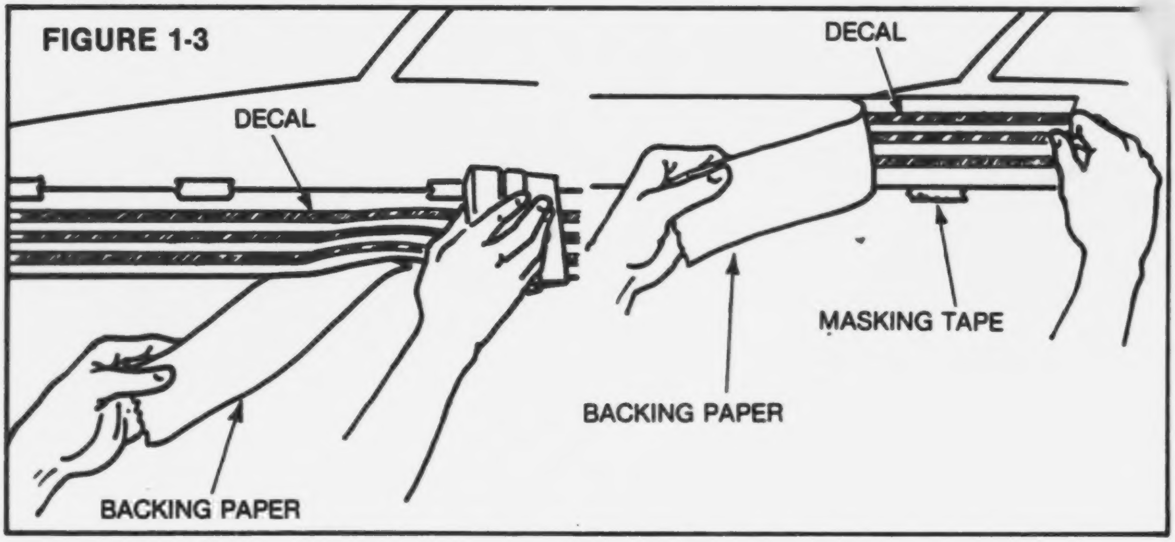
Procedure:

Evaluation:
3 2 1 N

11. Strip off about 6 inches of backing paper from one end. Fold decal into position and squeegee decal to panel with one hand while removing paper with the other. Remove about six inches of paper at a time. __ __ __ __

*(**CAUTION:** If any air bubbles are trapped, stop immediately and remove bubbles by lifting edge of decal and applying squeegee, moving from center outward to edge. Extremely small air bubbles can be repaired later.)*

FIGURE 1-3



12. Wrap end of decal, if possible, around door or panel break, being careful to avoid trapped air. __ __ __ __

13. Remove easy-release paper, if present, and check and repair small air bubbles by puncturing with a sharp needle and applying heat. __ __ __ __

Average of above evaluations* __ __ __ __

(*This average is the evaluation for Competency P4 "Remove and replace decals and stripes.")

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT II: VINYL TOPS

UNIT II TEST

I. Select the best answer from the choices listed.

_____1. A landau top is one that: (a) has opera windows, (b) is fastened with reveal moldings only, (c) is only half vinyl, (d) is composed of textured paint, (e) cannot be repaired.

_____2. Vinyl tops may be glued directly to the roof panel or they may be glued to: (a) retaining clips or drive nails, (b) a foam pad or retaining clips, (c) a foam pad or a plastic cap, (d) a plastic cap or retaining clips, (e) a plastic cap or drive nails.

_____3. In areas where vinyl tops extend into windshield or back window openings, they are attached with bonding adhesive and clips, drive nails or: (a) reveal moldings and finishing lace, (b) tabbed retainers, (c) tabbed retainers and finishing lace, (d) weatherstrip, (e) a heat gun.

_____4. In areas where vinyl tops do not extend into window openings and where there are no reveal moldings, they are attached with: (a) bonding adhesive, (b) tabbed retainers, (c) finishing lace, (d) any of the above, (e) none of the above.

_____5. Which of the following is NOT used in installing vinyl tops in areas where the top extends around drip moldings or folds around roof-panel flanges: (a) tabbed retainers, (b) adhesive, (c) drip-scalp moldings, (d) weatherstrip retainers, (e) finish moldings.

_____6. In using bonding adhesive the maximum heat application from a heat gun is: (a) 180° F, (b) 200° F, (c) 212° F, (d) 220° F, (e) 240° F.

_____7. Bonding adhesive is applied by: (a) a bonding roller, (b) compressed air, (c) a special brush, (d) a heat gun, (e) a clean cloth.

_____8. Which of the following is NOT a property of liquid vinyl: (a) bonds to vinyl, (b) is a paste, (c) is cured by heat, (d) has a grain, (e) comes in colors.

_____9. In applying liquid vinyl, you must use a die to: (a) remove wrinkles, (b) impart grain, (c) smooth the vinyl, (d) control the heat, (e) cure the bond.

_____10. Wrinkles in vinyl may be removed without lifting the top and reapplying adhesive by using: (a) hot water, (b) a heat gun, (c) a household iron, (d) a hammer and dolly (e) either a or b.

(NOTE: Completion of this unit test with a minimum score of _____ is necessary for the student to receive evaluations for Competencies P1 "Remove and replace vinyl tops," P2 "Repair vinyl tops," and P3, "Refinish vinyl tops.")

ANSWERS TO UNIT II TEST

1. C
2. A
3. A
4. D
5. A
6. B
7. B
8. D
9. B
10. C

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT III: INTERIOR TRIM

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify and service interior trim and interior components. Mastery will be evidenced through demonstration and by scoring _____ per cent on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Match terms with their definitions or illustrations (Competency Q1, Part I of Unit III test)

II. Identify interior trim locations (Competency Q1, Part I of Unit III test)

III. Identify procedures to protect interior trim (Competency Q1)

IV. Identify repairable trim (Competency Q1)

V. Identify headliner assemblies (Competency Q1)

Lesson 2:

I. Identify terms and definitions associated with interior detailing (Competencies Q2-Q6, Part II of Unit III test)

II. Identify typical fabrics and applications (Competencies Q2-Q6, Part II of Unit III test)

III. Identify general guidelines for stain removal (Competencies Q2-Q6, Part II of Unit III test)

IV. Identify stain removal guidelines for common stains (Competencies Q2-Q6, Part II of Unit III test)

V. Demonstrate the ability to:

   a. Clean plain interior fabrics (Competency Q2, Job Sheet #1)

   b. Clean coated interior fabrics, genuine leather and plastic molding interior components (Competency Q3, Job Sheet #2)

   c. Clean polyurethane foam interior components (Competency Q4, Job Sheet #3)

   d. Clean painted interior surfaces (Competency Q5, Job Sheet #4)

   e. Clean black-rubber interior surfaces and weatherstrip (Competency Q6, Job Sheet #5)

Lesson 3:

I. Identify seats and seat track construction (Competencies Q7-Q8, Part III of Unit III test)

II. Identify principles of removing seats (Competencies Q7-Q8, Part III of Unit III test)

III. Identify principles of servicing and installing seat belts (Competency Q12)

IV. Identify principles servicing carpeting (Competency Q11)

V. Identify principles of servicing dash assemblies (Competencies Q9-Q10)

VI. Demonstrate the ability to:

  a. Remove and replace seats (Competency Q7, Job Sheet #1)

  b. Remove and replace seat tracks (Competency Q8, Job Sheet #2)

  c. Remove and re-install seat belts (Competency Q12, Job Sheet #3)

  d. Remove and re-install carpeting (Competency Q11, Job Sheet #4)

  d. Remove and re-install dash assembly (Competency Q9, Job Sheet #5)

  e. Remove and re-install heating and air conditioning assembly (Competency Q10, Job Sheet #6)

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT III: INTERIOR TRIM

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. References

D. Lesson plans

1. Lesson 1: Identifying Interior Trim

    a. Information outline

2. Lesson 2: Interior Detailing

    a. Information outline

    b. Job sheets

    JS#1: Clean plain interior fabrics
    JS#2: Clean coated interior fabrics, genuine leather, and molded plastic interior components
    JS#3: Clean polyurethane foam interior components
    JS#4: Clean painted interior surfaces
    JS#5: Clean black rubber interior surfaces and weatherstripping

3. Lesson 3: Seats, Carpeting and Dash Assembly

    a. Information outline

    b. Job sheets

    JS#1: Remove and replace seats
    JS#2: Remove and replace seat tracks, manual or electric
    JS#3: Remove and replace seat belts
    JS#4: Remove and replace carpeting
    JS#5: Remove and replace dash assembly
    JS#6: Remove and replace heating and air conditioning assembly

E. Unit test

F. Answers to unit test

REFERENCES USED IN WRITING THIS UNIT

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2. Czapskie, George S., et. al. *Auto Body Repair.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1977.

3. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL 1984.

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6. Mitchell Information Services, Inc. *Body and Mechanical Parts Service & Repair, Domestic Cars, 1981-85.* Mitchell Information Services. San Diego, CA. 1985.

7. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

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MODULE: EXTERIOR AND INTERIOR TRIM

UNIT III: INTERIOR TRIM

LESSON ONE: IDENTIFYING INTERIOR TRIM

I. **Terms and definitions**

A. Arm rest -- Cushioned support attached to inside of door panel.

B. Backrest -- The upright part of a seat assembly.

C. Clothes hanger -- Small hook attached to the side roof panel in the rear quarter area.

D. Cushion -- The bottom part of a seat assembly.

E. Floor console -- Molded unit bolted to floor between bucket-type seats in some vehicles, with a variety of uses, including storage.

F. Floor pan insulators -- Insulation between floor pan and carpet on some vehicles to guard against heat of catalytic converters.

G. Firewall liner -- Sound-deadening material which covers the inside of the firewall.

H. Garnish molding -- Interior molding which fits around the edges of the front and back glass and covers the attachment point for the headliner.

I. Headliner -- The material covering the roof panel of the interior.

J. Kick panel -- The panel of durable material between the cowl and front-door opening on each side of the vehicle.

K. Pillar trim -- Trim which covers the interior of the center pillar.

L. Parcel shelf -- The flat area between the back seat backrest and the rear window.

M. Quarter trim panel -- Panel shaped to fit over quarter-panel interior.

N. Quarter trim upper panel -- Panel shaped to fit over upper quarter-panel area and includes the opening of any quarter window. Also called roof side trim panel.

O. Rearview mirror support -- Support which holds the rearview mirror and attaches to the windshield, or just above the windshield.

P. Seat belt attachment -- Anchoring points for front and rear seat belts.

Q. Side mirror control -- Lever on inside of vehicle for controlling movement of outside rearview mirror.

R. Step plate -- Panel, usually metal, which fits into the lower edge of the door openings and holds the floor covering in place.

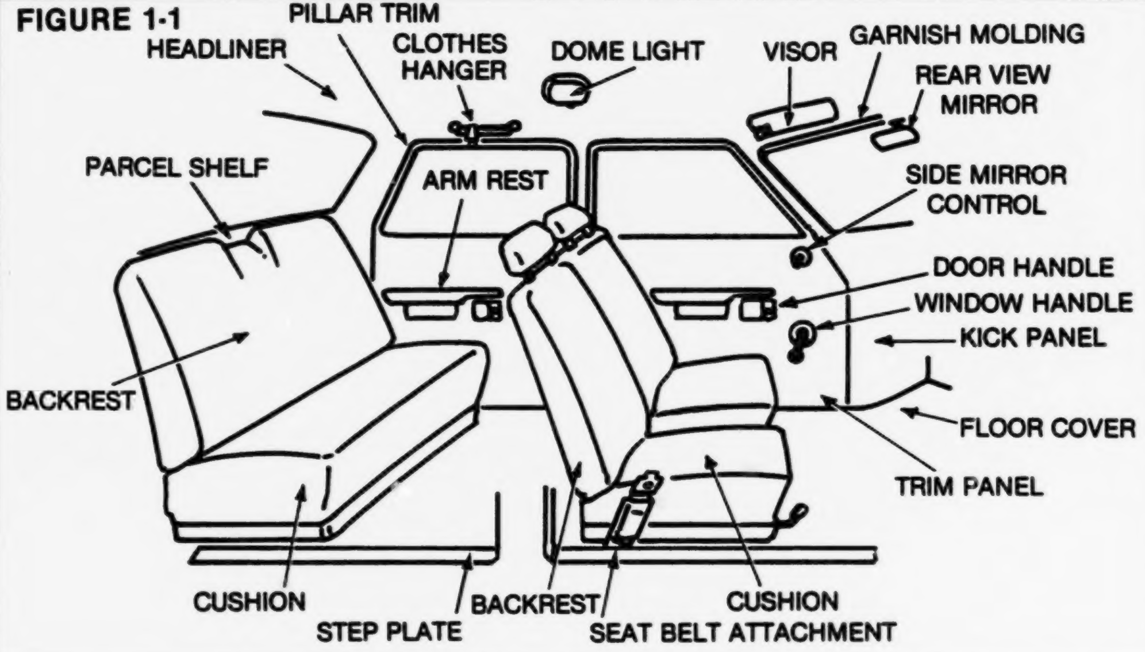
S. Trim panel -- Plastic, cloth, vinyl or leather panel which covers inside of door or other panels.

T. Visor -- Device located at inside front of roof panel which can be lowered to shade driver's or passenger's eyes.

U. Weatherstripping -- Molded rubber or urethane used to seal windows and doors.

II. Interior trim identification (FIG. 1-1)

FIGURE 1-1


PILLAR TRIM
HEADLINER
CLOTHES HANGER
DOME LIGHT
VISOR
GARNISH MOLDING
REAR VIEW MIRROR
PARCEL SHELF
ARM REST
SIDE MIRROR CONTROL
DOOR HANDLE
WINDOW HANDLE
KICK PANEL
BACKREST
FLOOR COVER
TRIM PANEL
CUSHION
STEP PLATE
BACKREST
SEAT BELT ATTACHMENT
CUSHION

III. Protecting interior trim

A. All vehicles in the shop should have their interiors protected at all times. Interiors are easily damaged.

B. Tips on protecting interior

1. Do not enter vehicles with greasy or soiled clothes unless interior is protected with coverings.
2. Keep vehicle doors, windows, and trunks closed at all times. If they must be opened, cover interior components thoroughly.
3. Beware of sharp objects protruding from your pockets when entering vehicle.
4. Do not set objects on seats or other interior components.
5. Remove any interior trim which may be damaged during other repair operations. Be especially aware of performing any welding operations in areas adjacent to interior trim.

IV. Identifying repairable trim

A. Trim which can be economically repaired

1. Dash assemblies

   a. For vinyl repair refer to "Vinyl roof repair," Unit II, this module.

   b. For plastic repair refer to Unit IV, Module 3.

2. Carpeting

   a. Carpeting replacement sections can be cut and installed.

   b. Refer to manufacturer's guidelines.

3. Seat coverings

   a. Normally handled by upholstery specialist.

   b. Complete seat cover may be replaced in body shop.

   c. Refer to manufacturer's guidelines.

B. Normally all other interior trim damaged in a collision will be replaced, although some modern plastic components can be repaired.

V. Headliner assemblies

A. Soft headliners

1. Covered with cloth or vinyl coating

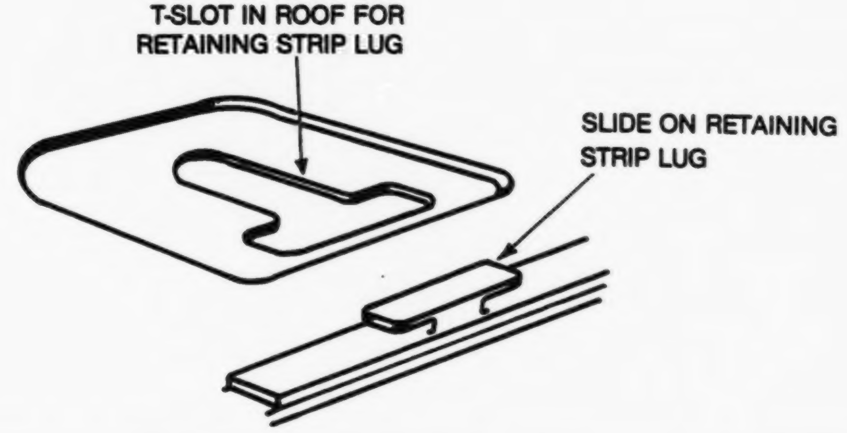
2. Attached to roof by plastic retaining strips

   a. Retaining strips sewn into headlining

   b. Contain rectangular lugs

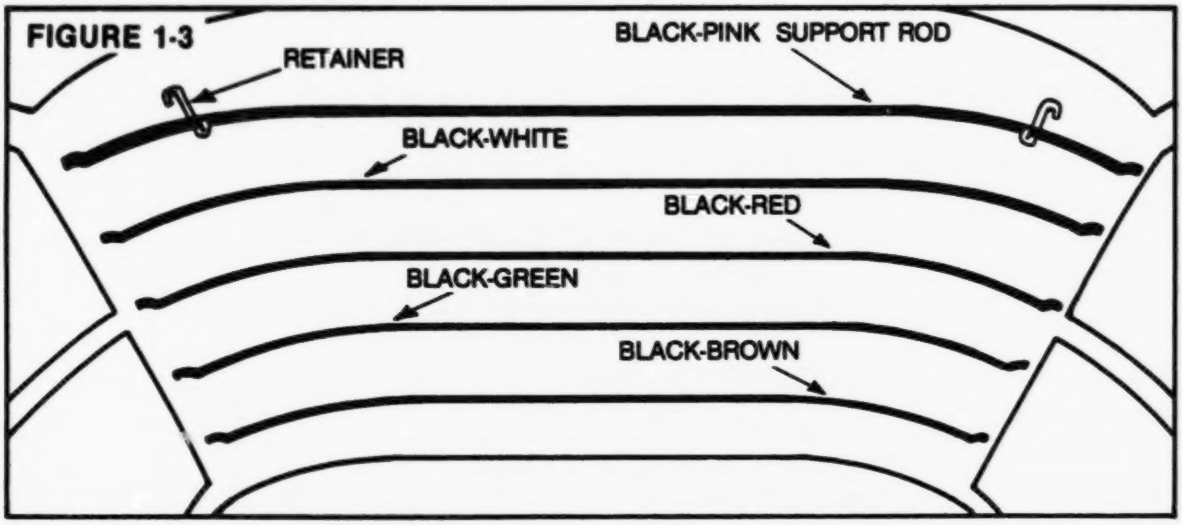
   c. Lugs fit in T-slots of roof panel (FIG. 1-2)

FIGURE 1-2


T-SLOT IN ROOF FOR
RETAINING STRIP LUG
SLIDE ON RETAINING
STRIP LUG

3. Attached to roof by support rods
   a. Pockets sewn into headlining
   b. Support rods pushed through pockets
   c. Support rods push into holes in roof rails

FIGURE 1-3


RETAINER
BLACK-PINK SUPPORT ROD
BLACK-WHITE
BLACK-RED
BLACK-GREEN
BLACK-BROWN

4. Both styles attached at edges by garnish molding or lace and adhesive.

B. Molded headliners

1. Formed from a variety of materials

2. One-piece or two-piece type
3. Held in place by tabs, or clips

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT III: INTERIOR TRIM

LESSON TWO: INTERIOR DETAILING

I. **Terms and definitions**

   A. Coated fabric -- Vinyl-covered or nylon-covered cloth.

   B. Detailing -- Restoring a vehicle to its best appearance by cleaning, repairing or replacing components.

   C. Plain fabric -- Any non-coated fabric.

   D. Neutral soap -- Mild liquid or solid cleaners, such as dishwashing liquids and saddle soap, not containing additives.

   E. Trim material -- Any material used to make interior trim.

   F. Volatile cleaner -- Any colorless, fast-evaporating, flammable liquid cleaner expressly for removing strains from fabrics.

II. **Typical fabrics and applications**

   A. Coated fabrics

      1. Seat coverings

      2. Trim panels

      3. Headliners

   B. Leather

      1. Seat coverings

   C. Molded plastics

      1. Dash board panel and trim panel components

      2. Kick panels

      3. Garnish moldings

      4. Console panels

   D. Painted surfaces

      1. Dash board panel shells and steering columns

      2. Garnish moldings

   E. Plain fabrics

   1. Seat coverings
   2. Trim panel inserts
   3. Headliners

F. Polyurethane foam

   1. Headliners

G. Rubber

   1. Floormats
   2. Foot pedals
   3. Knobs

III. General guidelines for all stain removal

1. Use a clean white cloth for all rubbing and blotting operations.
2. Rub or blot thoroughly until no stain is being transferred and use fresh area of cloth for each rubbing or blotting operation.
3. Rub from edge of stain inward to avoid spreading stain.
4. After removing stains, shampoo vinyl surfaces or use upholstery cleaners designed for automotive use.
5. Some upholstery and vinyl dies can be used to restore original grain – consult recommendations of die manufacturer.
6. Normal soil stains can be removed by a solution of mild, neutral soap and warm water. Normal soil on coated fabrics and molded plastic can be removed with upholstery cleaners designed for automotive use.

IV. Stain removal guidelines for common stains

(NOTE: The guidelines are arranged in the order they should be performed. If step one does not work completely, go on to step two, etc.)

A. Blood

(NOTE: Do not use hot water or soap and water – it will set the stain.)

   1. Rub with cold water cloth until no more stain will come out.
   2. Saturate with a small amount of 5:1 water-ammonia solution, wait one minute, then continue to rub with cold water on a clean cloth.
   3. Apply a thick paste of cornstarch and cold water. Allow to dry and wipe off. Repeat as needed.

B. Candy

1. Non-chocolate

   a. Rub with clean cloth soaked in hot water.

   b. If hot water fails, rub with a small amount of volatile cleaner on a cloth.

2. Cream- and fruit-filled chocolates

   a. Rub with lukewarm water and mild, neutral soap, then scrape with a dull knife while still wet. Rinse with a cold water cloth.

3. Chocolate and milk chocolate

   a. Rub with lukewarm water.

   b. After dry, rub lightly with volatile cleaner on cloth.

   c. Blot to remove excess cleaner and chocolate stain.

C. Catsup

1. Sponge with cool water.

2. Rub detergent on stain, working into fabric and rinse with wet cloth.

D. Chewing gum

1. Harden gum with ice cubes.

2. Scrape off with dull knife.

3. If ice fails, wet with volatile cleaner and work loose with dull knife while still wet.

E. Fruit, alcoholic beverages

1. Rub vigorously with very hot water on a cloth.

2. If hot water fails, allow to dry, then rub lightly with volatile cleaner.

3. DO NOT use soap and water and DO NOT apply heat to dry the fabric.

F. Grease and oil

1. Scrape off as much as possible with a dull knife.

2. Rub lightly with volatile cleaner, being sure motions are toward center of stain.

3. Blot with clean cloth.

G. Ice cream

1. Use same procedure as for fruit and alcoholic beverages.

2. If this fails, try warm soap and water, followed by a cold water rinse cloth, followed by a light rubbing with a volatile cleaner.

H. Ink

1. Difficult to remove

2. Sponge with cool water, work in a detergent and rinse with wet cloth.

I. Lipstick

1. Difficult to remove

2. Try a volatile cleaner.

3. If repeated applications of volatile cleaner do not work, it is best to leave stain.

J. Mud

1. Allow to dry.

2. Break up dried mud, brush off, and vacuum.

K. Mustard

1. Difficult to remove

2. Sponge with warm water, work in a detergent and rinse with cloth. Repeat.

L. Shoe polish

1. Liquid-based polishes

   a. After dry, brush with a brush.

   b. Moisten with cold water, let dry, and brush again.

2. Paste- or wax-based polishes

   a. Attempt procedure for liquid-based polish.

   b. Try volatile cleaner, rubbing toward center.

M. Tar

1. Use dull knife.

2. Wet lightly with volatile cleaner and use dull knife. Use caution as cleaner will dissolve tar and may cause it to run onto adjacent areas.

3. Rub lightly with volatile cleaner.

N. Urine

1. Sponge with lukewarm mild neutral soap and rinse with cold water.

2. Saturate cloth with 5:1 solution of water and household ammonia. Apply and let stand one minute, then rinse with water.

O. Vomit

1. Sponge with cold water, then wash lightly with mild, neutral soap and lukewarm water.

2. If odor persists, treat with 1 teaspoon baking soda to one cup tepid water, then rub with cold water on a cloth.

3. If stain persists, gently rub with volatile cleaner.

UNIT III

JOB SHEET #1, LESSON TWO

CLEAN PLAIN INTERIOR FABRICS

Equipment:

Vacuum cleaner
Clean rags
Sponge
Detergent
Ammonia
Bucket of lukewarm water
Upholstery brush
Rubber gloves

(NOTE: The steps of this procedure should be continued until the fabric is clean. Stop after the step which results in the removal of soil or stain.)

Procedure:	**Evaluation:** 3	2	1	N
1. Vacuum fabric.	___	___	___	___
2. Put on rubber gloves, make solution of detergent, ammonia and lukewarm water.	___	___	___	___
3. Apply solution to surface of fabric with brush, work into small area. Remove dirt and solution with wet rag or sponge, or with wet vacuum.	___	___	___	___
4. Repeat step 3, if needed. *(NOTE: If cleaning a large area, always work from inside to outside and from top to bottom.)*	___	___	___	___
5. Rub component with clean cloth to remove additional dirt and to help dry. Allow fabric to dry.	___	___	___	___
6. Repeat steps 3-5 if needed.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency Q2 "Clean plain interior fabrics.")

UNIT III

JOB SHEET #2, LESSON TWO

CLEAN COATED INTERIOR FABRICS, GENUINE LEATHER, AND MOLDED PLASTIC INTERIOR COMPONENTS

Equipment:

Sponge
Neutral soap
Clean rags
Bucket of lukewarm water
Rubber gloves

(NOTE: Do not use harsh cleaners or abrasive materials on coated fabrics, genuine leather, or molded plastics. Always squeeze excess water from sponge.)

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
1. Put on rubber gloves and mix solution of neutral soap and lukewarm water.	___	___	___	___
2. Apply solution to component with sponge.	___	___	___	___
3. Before soap dries, remove suds with a second sponge dampened with lukewarm water.	___	___	___	___
4. Wipe immediately with clean cloth.	___	___	___	___
5. Repeat steps 1-4 if necessary.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency Q3 "Clean coated interior fabrics, genuine leather, and molded plastic interior components.")

UNIT III

JOB SHEET #3, LESSON TWO

CLEAN POLYURETHANE FOAM INTERIOR COMPONENTS

Equipment:

Sponges
Mild detergent
Two buckets of warm water
Rubber gloves

(NOTE: Be especially cautious in cleaning polyurethane foam. It is a delicate material. Do not use a vacuum or broom. Wring out sponge in procedure below, leaving only suds.)

Procedure:	**Evaluation:** 3	2	1	N
1. Put on rubber gloves and mix mild detergent solution.	___	___	___	___
2. Use sponge to apply suds to a section of polyurethane surface. *(NOTE: Clean only a small portion, then another small portion, etc.)*	___	___	___	___
3. Rinse with a second sponge dampened with clean water.	___	___	___	___
4. Repeat steps 2-4 until component is clean, then dry surface carefully.	___	___	___	___
5. If needed, repeat steps 2-4 again.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency Q4 "Clean polyurethane foam interior components.")

UNIT III

JOB SHEET #4, LESSON TWO

CLEAN PAINTED INTERIOR SURFACES

Equipment:

Sponges
Neutral soap
Bucket of warm water
Clean rags
Rubber gloves

(NOTE: On low-gloss painted interior surfaces, do not use abrasive exterior polishes or waxes. On glossy surfaces, it is acceptable to use an exterior wax.)

	Procedure:	**Evaluation:** 3	2	1	N
1.	Put on rubber gloves and mix solution of neutral soap and lukewarm water.	___	___	___	___
2.	Apply solution to component with sponge.	___	___	___	___
3.	Before soap dries, remove suds with a second sponge dampened with lukewarm water.	___	___	___	___
4.	Wipe immediately with clean cloth.	___	___	___	___
5.	Repeat steps 1-4 if necessary.	___	___	___	___
	Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency Q5 "Clean painted interior surfaces.")

UNIT III

JOB SHEET #5, LESSON TWO

CLEAN BLACK RUBBER INTERIOR SURFACES AND WEATHERSTRIPPING

Equipment:

Volatile cleaner
Clean rags
Rubber and vinyl cleaner
Rubber gloves

Procedure:	Evaluation: 3	2	1	N
1. Move vehicle to well-vented area and put on rubber gloves.	___	___	___	___
2. Saturate rag with volatile cleaner and wipe component.	___	___	___	___
3. Following manufacturer's recommendation, clean surface with rubber or vinyl cleaner.	___	___	___	___
4. Continue steps 2-3 until all surfaces are clean.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency Q6 "Clean black rubber interior surfaces and weatherstrip.")

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT III: INTERIOR TRIM

LESSON THREE: SEATS, CARPETING AND DASH ASSEMBLY

I. **Types of seats**

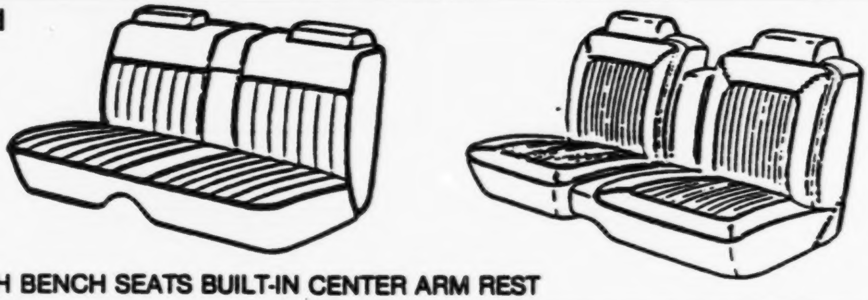
A. Manual front seats in two-door vehicles, non-bucket styles. (FIG. 3-1)

1. Two seat tracks, one on each side
2. Manual seat-track adjustment, forward or backward
3. May have separate controls on each side for adjusting angle of backrest.
4. Seat back latch to allow passengers to enter rear seats.

   (NOTE: Front seats in four-door vehicles do not have a seat back latch and generally do not fully recline.)

5. Adjustable head restraints on all newer cars

FIGURE 3-1



FULL-WIDTH BENCH SEATS BUILT-IN CENTER ARM REST

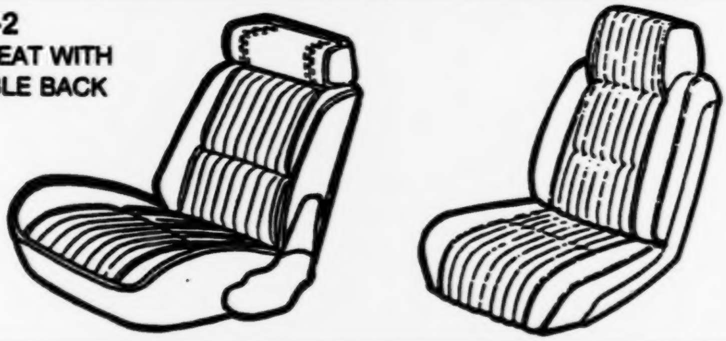
General Motors Corporation, 1987, used with permission

B. Bucket seats (FIG. 3-2)

1. Four seat tracks -- two for each seat
2. Manual seat-track adjustment, forward or backward
3. Separate controls on each side for adjusting angle of backrest
4. Integral head restraint on all newer cars

5. Some models swivel, with a separate manual control lever allowing the seat to swing, usually only to the outside of the vehicle for easier exit and entry.

FIGURE 3-2



BUCKET SEAT WITH ADJUSTABLE BACK

STANDARD BUCKET SEAT

General Motors Corporation, 1987, used with permission

C. Power front seats

1. Variety of designs, both bucket and bench

2. Use electric motor powered by vehicle battery

3. May be four-way or six-way

   a. Four-way has two motors, one for forward-backward movement, one for moving seat up and down.

   b. Six-way has three motors; in addition to same functions as four-way, a third motor tilts the seat forward or backward.

4. Troubleshooting power seat problems is a matter of isolating the problem as electrical or mechanical.

D. Back seats

1. Usually bench seats - variety of styles.

2. Seat backs attach to vehicle and do not adjust, except on hatchback styles.

3. Rear seat backs in hatchbacks pivot fully forward to convert rear of compartment to luggage/utility compartment.

   (NOTE: In removing hatchback rear seats, be especially careful not to lose the specially designed pivot bolts.)

II. Seat tracks

A. Allow front seats to be moved forward or backward.

B. Are bolted to floor pan with studs, nuts and washers

1. On some vehicles nuts are removed from inside vehicle.

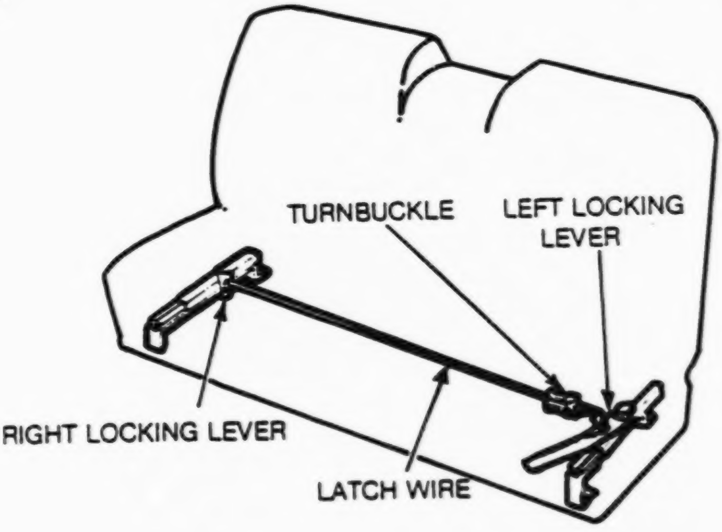
2. On some vehicles nuts are removed from outside vehicle.

C. Front seats are generally removed by unbolting the seat tracks and removing tracks and seat as a unit.

D. Manual seat-track locking mechanisms sometimes need adjustment by adjusting the locking wire to increase or decrease tension.

E. The locking level may also need some adjustment by increasing or decreasing the tension, usually by adjusting a turnbuckle. (FIG. 3-3)

FIGURE 3-3



III. Principles of seat removal

A. In many vehicle repair procedures it is necessary to remove the seats.

B. In removing seats, tearing upholstery or other damage is frequent unless special care is taken.

C. Front seats are removed from the seat tracks by removing the bolts holding the seat tracks to vehicle floor pan.

D. Usually it is necessary to remove the seat belts prior to removing bench-type front seats.

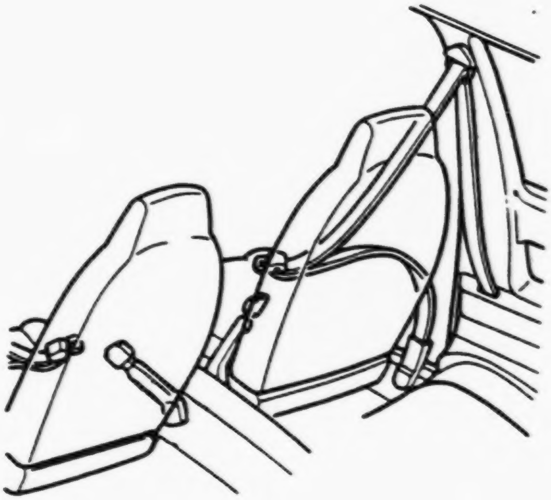
E. Seat upholstery repair is usually done by an upholstery shop. Hog rings hold the upholstery covering to the seat frame.

F. Store removed seats in a safe, dry area and cover to avoid damage from paint overspray, dirt, grease, etc.

G. Power seats are removed from the vehicle in the same way as manual seats. However, the wiring must be carefully disconnected first.

IV. Servicing seat belts (FIG. 3-4)

FIGURE 3-4



General Motors Corporation, 1987, used with permission

A. Check for belt webbing that is frayed, split, or torn.

B. Check belt buckles for proper operation.

C. Check belt anchor -- should not be loose, badly corroded, or missing, and should be fastened to the belt.

D. Belt mounting surfaces must not be deformed, damaged or corroded.

E. Check operation of belt retractors.

F. Mounting surface defects should be repaired.

G. Defects in belts, buckles, anchors and retractors require replacement of the part.

V. Installing seat belts

A. Never mix seat belt types -- use the exact replacement belt.

B. Keep sharp edges away from new belts.

C. Avoid bending belt buckle or latch plate.

D. Do not bleach or dye belt webbing.

VI. Carpeting

A. May be one-piece or two-piece

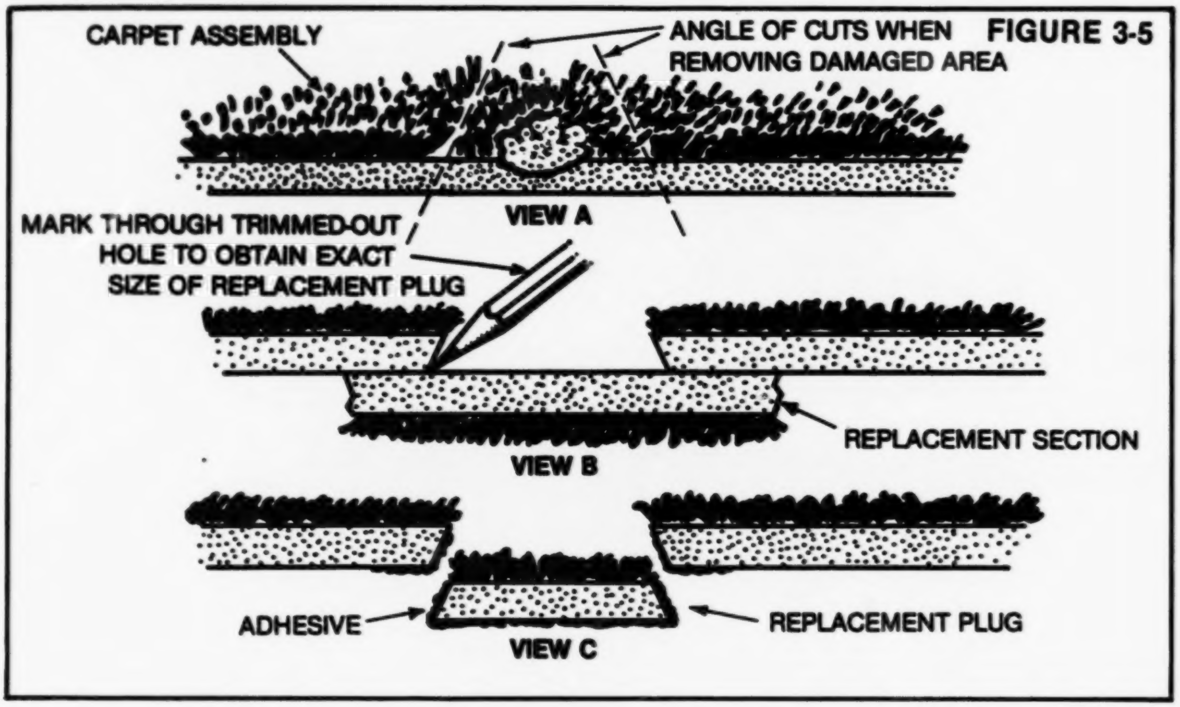
B. Two-piece carpets can be replaced without removing front seat(s).

C. One-piece carpets require the removal of front seat(s), and some other interior components, if present.

D. All carpets require the removal of the step plate.

E. Tears or small damage to carpets can be repaired by cutting a replacement section. (FIG. 3-5)

FIGURE 3-5


CARPET ASSEMBLY
ANGLE OF CUTS WHEN REMOVING DAMAGED AREA
VIEW A
MARK THROUGH TRIMMED-OUT HOLE TO OBTAIN EXACT SIZE OF REPLACEMENT PLUG
REPLACEMENT SECTION
VIEW B
ADHESIVE
REPLACEMENT PLUG
VIEW C

VII. Dash assemblies (FIG. 3-6)

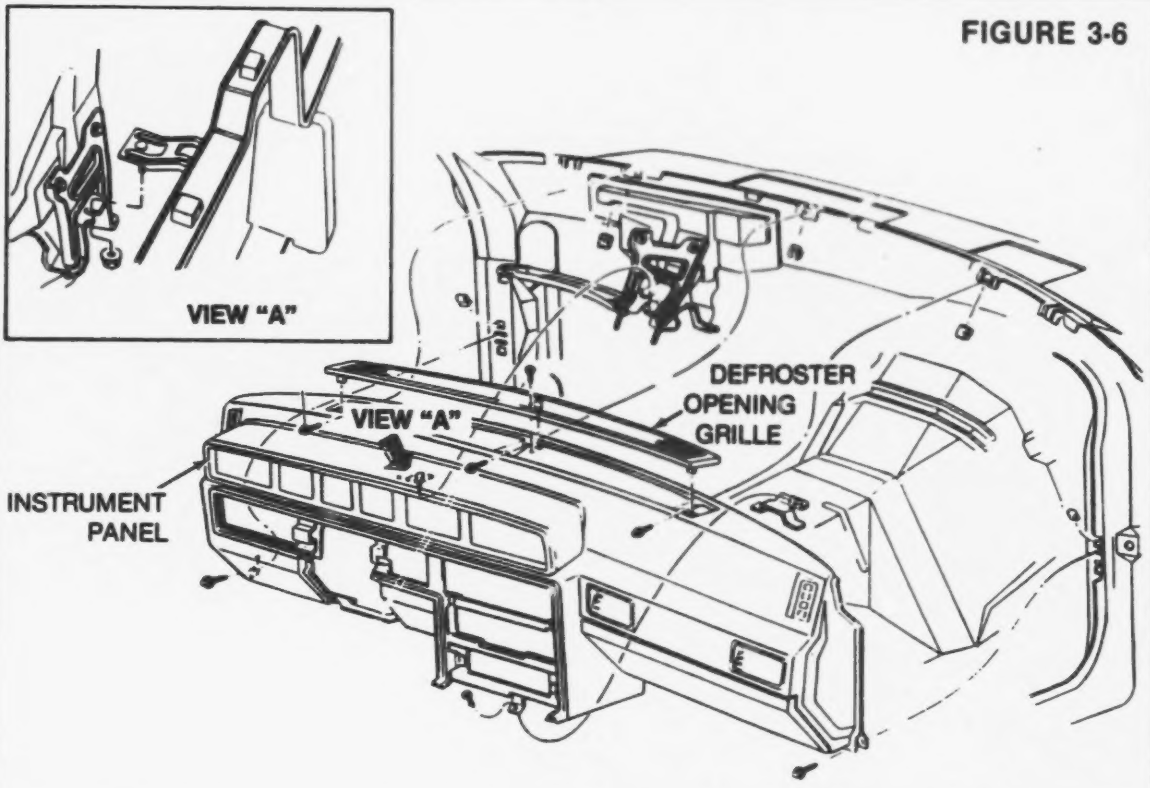


FIGURE 3-6

VIEW "A"
DEFROSTER OPENING GRILLE
VIEW "A"
INSTRUMENT PANEL

Used with permission of Mitchell International, Inc.

A. Serve multiple functions

1. Contain the instrument package for the vehicle.
2. House heating and/or air conditioning duct work, and heater core (if present).
3. Provide mounting point for steering column.

B. Dash panel replacement requires careful attention to vehicle service manual.

C. In removing dash assemblies, be careful not to damage wires or lose track of wiring locations.

UNIT III

JOB SHEET #1, LESSON THREE

REMOVE AND REPLACE SEATS

Equipment:

Common hand tools
Torque wrench
Cover for storage of seats
Safety glasses

(NOTE: The following job sheet is for evaluation purposes. Exact steps of procedure must be determined from vehicle service manual.)

Procedure:	**Evaluation:**			
	3	2	1	N
Operation #1: Removing rear seat				
1. Remove arm rest, if present, or other interior components in the way.				
2. Remove seat cushion by forcing lower edge of cushion to rear, then move it upward until disengaged.				
3. Remove cushion by lifting and moving forward until it can go out either rear door (4-door) or passenger door (2-door).				
4. Remove the rear seat back rest, following service manual guidelines.				
5. Re-install by reversing procedure.				
Average of above evaluations.				

Operation #2: Removing front seats, bench or bucket, manual or power

(NOTE: This procedure will require significant modifications depending on vehicle, but evaluation should follow same basic guidelines. For bucket seats, perform operation #2 twice.)

Procedure:	**Evaluation:**			
	3	2	1	N
1. Remove seat belt anchoring bolts where inner seat belts go through seat assembly, if necessary.				
2. Remove step plates and fold back carpeting to reveal seat installation bolts (This step will not be necessary on all installations.)				

Procedure:	Evaluation: 3	2	1	N
3. Move seat to rearmost position and remove front anchor bolts.	___	___	___	___
4. Move seat to frontmost position and remove rear anchor bolts.	___	___	___	___
5. With seat in maximum forward position and with the aid of an assistant, lift seat and remove from vehicle.	___	___	___	___
6. Reverse procedure to re-install.	___	___	___	___
7. After replacement, adjust seats as needed.	___	___	___	___
Average of operation #2 evaluations	___	___	___	___
Average of operation #1 and #2 evaluations*	___	___	___	___

(*This average is the evaluation for Competency Q7 "Remove and replace seats.")

UNIT III

JOB SHEET #2, LESSON THREE

REMOVE AND REPLACE SEAT TRACKS, MANUAL OR ELECTRIC

Equipment:

Common hand tools
Torque wrench
Safety glasses

(NOTE: Some electric seat tracks will differ slightly in their removal procedures. Always consult vehicle service manual.)

Procedure: **Evaluation:**
3 2 1 N

1. Perform operation #1, Job Sheet #1 to remove front seat. ___ ___ ___ ___

2. Place front seat assembly upside down on a clean, protected surface. ___ ___ ___ ___

3. On manual seat tracks, remove seat adjuster assist spring from adjuster being removed. ___ ___ ___ ___

   (NOTE: If removing right adjuster, squeeze hooked end of seat adjuster locking wire together and slide retaining spring over hump in locking wire and remove locking wire from adjuster.)

4. On power-operated seats, disconnect drive cables at adjuster being removed. ___ ___ ___ ___

5. Disconnect track-to-seat bottom frame front and rear attaching bolts or nuts and remove seat adjuster from seat. ___ ___ ___ ___

   (NOTE: On some seats, spacers are installed between the seat adjusters and seat frame. Note location of spacers for re-installation in same positions.)

6. After performing repair or replacement of components, reconnect seat tracks and check operation of adjusters. (On power seats, check that both adjusters are parallel and in phase with each other. If out of phase, consult service manual.) ___ ___ ___ ___

7. Reconnect adjuster assist spring (manual) or drive cables (power). ___ ___ ___ ___

Procedure:	**Evaluation:** 3 2 1 N
8. Re-install seat by reversing procedure from Job Sheet #1, operation #1.	___ ___ ___ ___
Average of above evaluations*	___ ___ ___ ___

(*This average is the evaluation for Competency Q8 "Remove and replace seat tracks, manual.")

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UNIT III

JOB SHEET #3, LESSON THREE

REMOVE AND REPLACE SEAT BELTS

Equipment:

Common hand tools
Torque wrench
Safety glasses

(NOTE: The retractor portion of the seat-belt assembly must be replaced as a unit, with all its component parts. The buckle portion can be replaced as a separate unit. The job sheet below assumes the removal and replacement of both the retractor and the buckle assemblies for a front-seat installation. Be careful to keep seat belt assemblies away from sharp edges or damaging objects. Avoid bending or damaging any portion of the belt buckle or latch plate. Clean belts only with mild soap and water solution.)

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
1. Remove retractor cover, if necessary.	___	___	___	___
2. Remove bolts holding retractor to center pillar.	___	___	___	___
3. Remove D-ring bolt.	___	___	___	___
4. Remove bolt, holding buckle assembly.	___	___	___	___
5. Remove buckle and retractor assemblies.	___	___	___	___
6. Reverse procedure for re-installation, tightening all bolts to EXACT torque specifications. Start all bolts by hand to assure bolt is threaded straight.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency Q12 "Remove and re-install seat belts.")

UNIT III

JOB SHEET #4, LESSON THREE

REMOVE AND REPLACE CARPETING

Equipment:

Common hand tools
Cover for storage of seats
Safety glasses

(NOTE: The following job sheet is for evaluation purposes. Exact steps of procedure will have to be determined from vehicle service manual.)

	Procedure:	**Evaluation:** 3	2	1	N
1.	If necessary, remove seats by performing Job Sheet #1.	___	___	___	___
2.	Remove seat belts by performing Job Sheet #2.	___	___	___	___
3.	Remove step plate.	___	___	___	___
4.	Remove additional clips or fasteners required to remove carpet.	___	___	___	___
5.	Re-install new carpet, reversing steps of procedure above.	___	___	___	___
	Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency Q11 "Remove and re-install carpeting.")

UNIT III

JOB SHEET #5, LESSON THREE

REMOVE AND REPLACE DASH ASSEMBLY

Equipment:

Common hand tools
Battery cable puller
Cover for protecting interior components

(NOTE: Due to the wide variety of dash panel assemblies the following job sheet is for evaluation purposes only. Exact steps of procedure will have to be determined from vehicle service manual.)

Procedure:	**Evaluation:** 3	2	1	N
1. Disconnect battery cables.	___	___	___	___
2. Disconnect dash wiring assemblies as necessary.	___	___	___	___
3. Remove bolts or screws holding dash panel components in place.	___	___	___	___
4. Remove dash panel components which must be replaced.	___	___	___	___
5. Reverse steps of procedure for re-installation.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency Q9 "Remove and re-install dash assembly.")

UNIT III

JOB SHEET #6, LESSON THREE

REMOVE AND REPLACE HEATING AND AIR CONDITIONING ASSEMBLY

Equipment:

Common hand tools
Battery cable puller
Cover for protecting interior components

(NOTE: Due to the wide variety of heating and air conditioning assemblies, the following job sheet is for evaluation purposes only. Exact steps of procedure must be determined from vehicle service manual.)

Procedure:	**Evaluation:** 3	2	1	N
1. Disconnect battery cables.	___	___	___	___
2. Disconnect wiring assemblies as necessary.	___	___	___	___
3. Remove bolts or screws holding dash panel components in place which must be removed to gain access to heating and air conditioning unit.	___	___	___	___
4. Remove dash panel components which must be removed.	___	___	___	___
5. Remove heating and air conditioning components following service manual procedures.	___	___	___	___
6. Reverse steps of procedure for re-installation.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency Q10 "Remove and re-install heating and air conditioning assembly.")

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT III: INTERIOR TRIM

UNIT TEST

PART ONE–INTERIOR TRIM

From the list below, match the trim name with the letter on the illustration pointing to the trim.

_____1. Door handle

_____2. Arm rest

_____3. Trim panel

_____4. Step plate

_____5. Backrest

_____6. Seat belt attachment

_____7. Kick panel

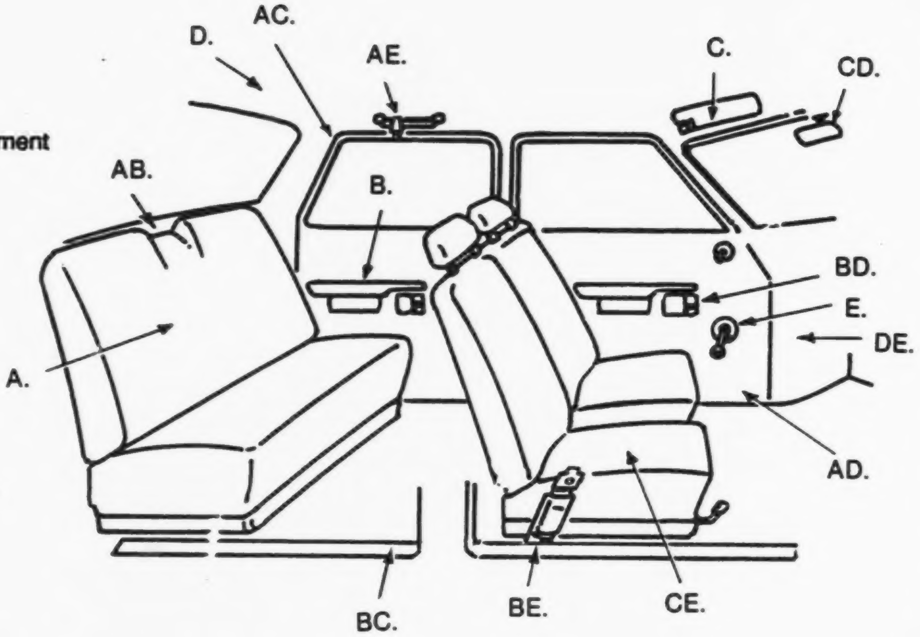
_____8. Pillar trim

_____9. Visor

_____10. Parcel shelf

_____11. Headliner

_____12. Window handle



(Completion of this portion of the unit test is the evaluation for Competency Q1 "Identify interior components and interior trim." Of the 12 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, and _____ correct or below, the student should retake this portion of the test.)

PART II--INTERIOR DETAILING.

I. Match the term in the left column with the most closely associated item in the right column.

_____13. Coated fabric
_____14. Detailing
_____15. Plain fabric
_____16. Rubber
_____17. Neutral soap
_____18. Volatile cleaner
_____19. Leather
_____20. Molded plastic
_____21. Painted surface
_____22. Polyurethane foam

A. Headliners in luxury models
B. Flammable liquid
C. Vinyl or nylon
D. Seat covers in luxury models
E. Kick panels
AB. Dash board panel shells
AC. Foot pedals
AD. Clean, repair, replace
AE. Most headliners
BC. Detergent with additives
BD. Detergent with no additives

II. Match the stain in the left column with the acceptable methods of removal in the right column. The removal methods may be used more than once.

_____23. Blood
_____24. Non-chocolate candy
_____25. Catsup
_____26. Chewing gum
_____27. Alcoholic beverage
_____28. Grease
_____29. Ink
_____30. Lipstick
_____31. Mud
_____32. Tar

A. Volatile cleaner
B. Cold water first, then ammonia, then cornstarch
C. Hot water first, then volatile cleaner
D. Cold water and detergent
E. Ice and dull knife
AB. Scrape with dull knife, then try volatile cleaner.
AC. Allow to dry, then brush

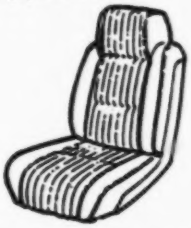
(NOTE: Completion of this portion of the unit test with a minimum score of _____% is necessary for the student to receive evaluation for Competencies Q2-Q6.)

PART III--SEATS

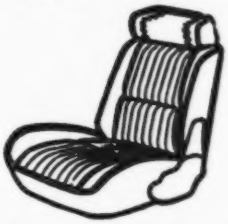
I. Select the best answer from the choices listed.

_____33. The number of seat tracks for a bench seat are: (a) two, (b) four, (c) six, (d) eight, (e) may vary.

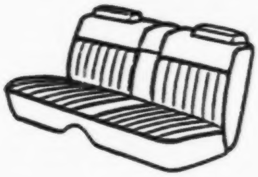
_____34. The type of seat in the illustration below is a: (a) bench seat, (b) 60-40 seat, (c) salon seat, (d) bucket seat, (e) 50-50 seat.



_____35. The type of seat in the illustration below is a: (a) bench seat, (b) 60-40 seat, (c) salon seat, (d) bucket seat, (e) 50-50 seat.



_____36. The type of seat in the illustration below is a: (a) bench seat, (b) 60-40 seat, (c) salon seat, (d) bucket seat, (e) 50-50 seat.



_____37. The number of motors in a six-way power seat is: (a) two, (b), three, (c) four, (d) five, (e) six.

_____38. Care must be taken in removing seats because: (a) danger of electric shock, (b) bolts are easy to lose, (c) seats are easily damaged, (d) seat tracks are easily damaged, (e) high-tension springs.

_____39. Care must be taken in replacing seat belts because: (a) seat belts are easily damaged, (b) the exact replacement must be used, (c) retractors are hard to re-install, (d) mountings are easily damaged, (e) all of the above.

_____40. The type of carpeting which requires removal of the seat before replacement is: (a) cut pile, (b) shag, (c) one-piece, (d) two-piece, (e) fiber-woven.

(NOTE: Successful completion of this portion of the unit test with a minimum score of _____ is necessary for the student to receive evaluations on Competencies Q7 and Q8.)

ANSWERS TO UNIT III TEST

PART I.

1. BD
2. B
3. AD
4. BC
5. A
6. BE
7. DE
8. AC
9. C
10. AB
11. D
12. E

PART II.

13. C
14. AD
15. AE
16. AC
17. BD
18. B
19. D
20. E
21. AB
22. A

23. B
24. C
25. D
26. E
27. C
28. AB
29. D
30. A
31. AC
32. AB

PART III.

33. A
34. E
35. D
36. A
37. B
38. C
39. B
40. C

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT IV: GLASS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify and service fixed and movable glass and identify and service door interior components. Mastery will be evidenced through demonstration and by scoring _____ per cent on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:
- I. Match terms with their definitions or illustrations (Competency R1, Unit IV test)
- II. Identify tools used in glass installation (Competency R1, Unit IV test)
- III. Identify vehicle glass (Competency R1, Unit IV test)
- IV. Identify safety in working with vehicle glass (Competency R1, Unit IV test)

Lesson 2:
- I. Identify windshield and back glass installation techniques (Competency R1, Unit IV test)
- II. Identify quarter-glass installation techniques (Competency R1, Unit IV test)
- III. Demonstrate the ability to:
  - a. Remove and replace a reveal molding (Competency R2, Job Sheet #1)
  - b. Remove and replace a gasket-type window or back glass (Competency R3, Job Sheet #2)
  - c. Remove and replace glass with urethane sealants (Competency R4, Job Sheet #3)
  - d. Remove and re-install glass with butyl tape kit (Competency R5, Job Sheet #4)
  - e. Install bonded mirror brackets to windshield (Competency R6, Job Sheet #5)

Lesson 3:
- I. Identify terms and definitions associated with door glass and door trim assemblies (Competency R1, Unit IV test)
- II. Identify door panel interior components (Competency R1, Unit IV test)

III. Identify methods of attaching door handles (Competency R1, Unit IV test)

IV. Identify methods of attaching arm rest (Competency R1, Unit IV test)

V. Identify principles of removing trim panel (Competency R1, Unit IV test)

VI. Identify window regulator assemblies (Competency R1, Unit IV test)

VII. Demonstrate the ability to:

   a. Remove and replace a clip-attached door handle (Competency R7, Job Sheet #1)

   b. Remove and replace a screw-attached door handle (Competency R7, Job Sheet #2)

   c. Remove and replace a door trim panel (Competency R8, Job Sheet #3)

   d. Remove and replace a lock cylinder (Competency R9, Job Sheet #4)

   e. Remove and replace door glass, channel attached (Competency R10, Job Sheet #5)

   f. Remove and replace door glass, bolt attached (Competency R10, Job Sheet #6)

   g. Remove and replace door glass regulator (Competency R11, Job Sheet #7)

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT IV: GLASS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. References

D. Lesson plans

1. Lesson 1: Principles of Vehicle Glass

    a. Information outline

2. Lesson 2: Stationary Glass Installation

    a. Information outline

    b. Transparency masters

        TM#1: Typical windshield installation
        TM#2: Using wire to cut adhesive
        TM#3: Using knives to cut adhesive

    b. Job sheets

        JS#1: Remove and replace a reveal molding
        JS#2: Remove and replace a gasket-type window or back glass
        JS#3: Remove and replace glass with urethane sealants
        JS#4: Remove and re-install glass with butyl tape kit
        JS#5: Install bonded mirror brackets to windshield

3. Lesson 3: Door Glass and Door Trim Assemblies

    a. Information outline

    b. Transparency masters

        TM#1: Trim panel and water deflector
        TM#2: Trim panel and door handle

    c. Job sheets

        JS#1: Remove and replace a clip-attached door handle
        JS#2: Remove and replace a screw-attached door handle
        JS#3: Remove and replace a door trim panel
        JS#4: Remove and replace a lock cylinder
        JS#5: Remove and replace door glass, channel attached
        JS#6: Remove and replace door glass, bolt attached
        JS#7: Remove and replace manual or electric door glass regulator

E. Unit test

F. Answers to unit test

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MODULE: EXTERIOR AND INTERIOR TRIM

UNIT IV: GLASS

LESSON ONE: PRINCIPLES OF VEHICLE GLASS

I. **Terms and definitions**

A. After-sealant -- A liquid butyl substance used in tape installations to fill cracks between windshield, tape and pinchweld.

B. Banana knife -- A long-bladed knife used to cut out windshields having a painted bottom.

C. Bruise -- A small crack that starts at the chipped edge of glass.

D. Butyl -- A synthetic rubber compound used in fixed-glass installations. May be either tape, or a liquid applied with a caulking gun.

E. Channel -- A section of U-shaped metal lined with felt. Reduces glass breakage, noise, and aligns window glass.

F. Channel-cleaning tool -- Special tool used to remove broken glass for glass channels.

G. Cold knife -- A tool used to remove non-gasket windshields. Also called windshield cut-out tool.

H. Fiber paddle -- A tapered-end tool made of fiberglass or plastic. Used to loosen the bond between a windshield in a gasket, and for similar installation procedures. Also called a trim stick.

I. Hooking tool -- A special tool used to install a windshield in a gasket.

J. Idler guides -- Devices that secure movable side windows.

K. Inner-shield five ply -- Laminated windshield glass with two extra vinyl layers on the inside surface.

L. Lacing tool -- Device with eyelet that treads on a locking strip and has a heel which presses the locking strip into the channel.

M. Laminated glass -- Glass with an inner and outer layer and a thin layer of clear vinyl between the layers.

N. Leak detector -- A tool that blasts air. Used to look for leaks in glass installations.

O. Molding release tool -- Tool used to remove molding clips from fixed glass.

P. Pinchweld -- A metal flange extending from the side pillars (A-pillars) of a vehicle into the windshield opening.

Q. Quarter glass -- Back windows in a two-door vehicle.

R. Release agent -- Liquid solvent used to help release a windshield from a rubber gasket.

S. Safety glass -- General term for either laminated or safety glass.

T. Setting block posts -- Posts on which a windshield sits and which hold it in place.

U. Shaded glass -- Laminated glass with colored inner vinyl layer.

V. Stress cracks -- Cracks in fixed glass which occur because of an improper fit or foreign matter in the seal.

W. Tempered glass -- Strong glass made by cooling the hot glass in water, making it five to ten times more resistant to shocks than other glass.

X. Tinted glass -- Glass to which a small amount of color has been added.

Y. Urethane -- A sealant with extremely strong bonding properties used in many late-model vehicles for fixed- glass installation.

Z. Window regulator -- Device used to raise and lower door glass.

II. **Tools used in glass installation** (FIG. 1-1)

A. Utility knife

B. Lacing tool

C. Door handle clip tool

D. Molding chisel and scraper

E. Trim stick

F. Mirror bracket wrench

G. Windshield cut-out knife

H. Door panel removing tool

I. Molding tool

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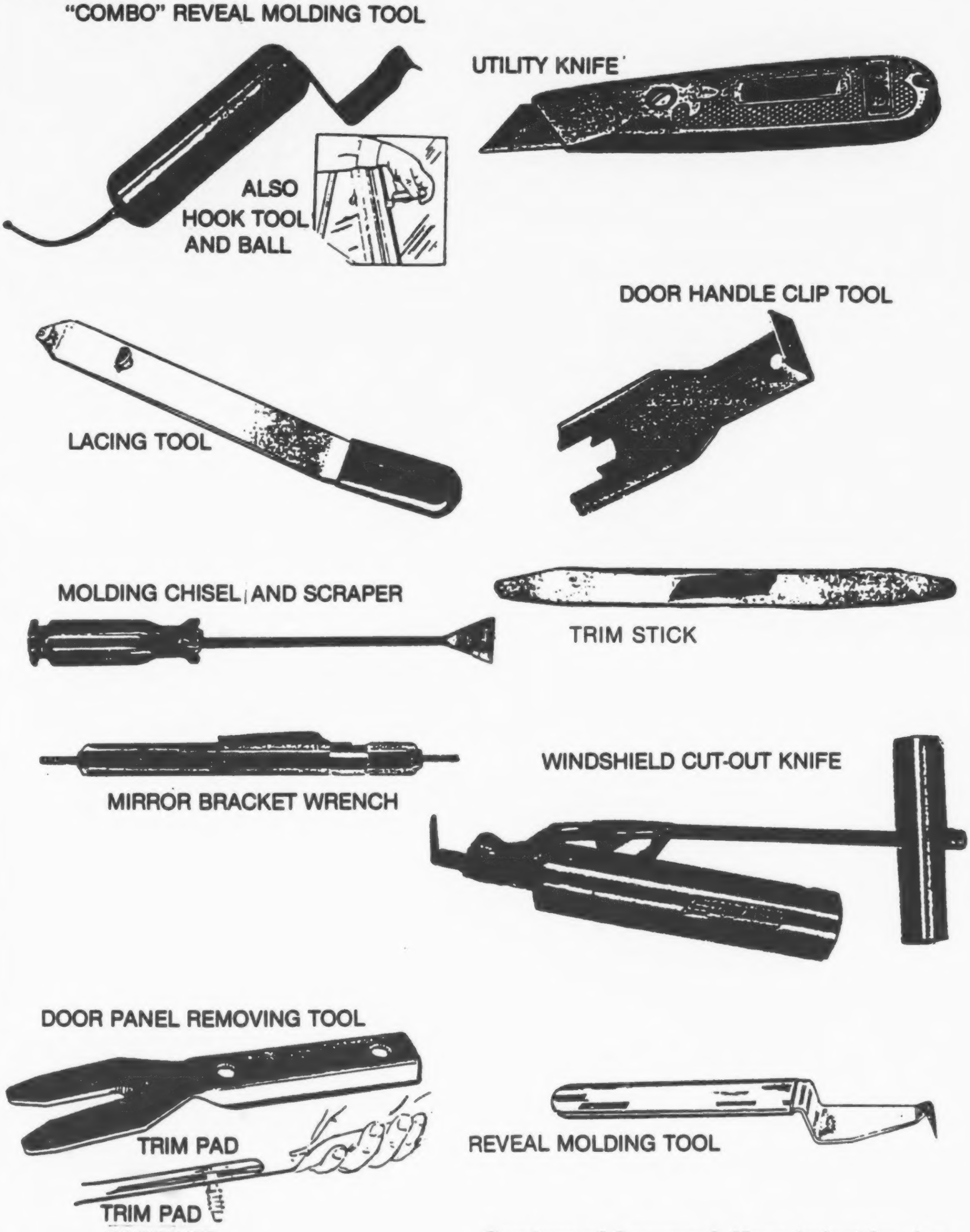
FIGURE 1-1


"COMBO" REVEAL MOLDING TOOL
UTILITY KNIFE
ALSO
HOOK TOOL
AND BALL
DOOR HANDLE CLIP TOOL
LACING TOOL
MOLDING CHISEL AND SCRAPER
TRIM STICK
WINDSHIELD CUT-OUT KNIFE
MIRROR BRACKET WRENCH
DOOR PANEL REMOVING TOOL
TRIM PAD
REVEAL MOLDING TOOL
TRIM PAD
FASTENER

Courtesy of Sommer & Maca Industries, Inc.

III. Vehicle glass

- A. Locations
  - 1. Windshield
  - 2. Back glass
  - 3. Door windows
  - 4. Quarter windows
  - 5. Sun roofs
- B. Types
  - 1. Laminated glass
    - a. Used in windshields
    - b. Vinyl layer between inner and outer glass
    - c. If broken, glass fragments cling to vinyl
  - 2. Tempered glass
    - a. Used in door, quarter, and back glass
    - b. Cooled in forming process - five to ten times stronger than other glass
    - c. Breaks into small fragments with dull edges, resembling rock salt
  - 3. Inner-shield five-ply
    - a. Used in windshields in late-model vehicles
    - b. Two additional layers of vinyl on inside
    - c. Added safety for passengers in accident
- C. Additional features of some vehicle glass
  - 1. Shaded
    - a. Vinyl in laminated glass is colored
    - b. Provides glare reduction and reduces sun's heat in vehicle
  - 2. Tinted
    - a. Glass itself is colored
    - b. Provides glare reduction and reduces sun's heat in vehicle

IV. Safety

A. Safety is extremely important in working with vehicle glass.

B. Protect vehicle interior with covers.

C. Protect vehicle exterior with covers.

D. Protect self with safety glasses and heavy gloves.

E. Handle glass carefully.

F. Use steel-toed shoes.

G. When carrying glass hold it so it can only fall away from you.

H. Hold glass vertically with palm of lower hand turned outward. Two people carrying glass should hold it the same way. Never carry glass under arms.

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT IV: GLASS

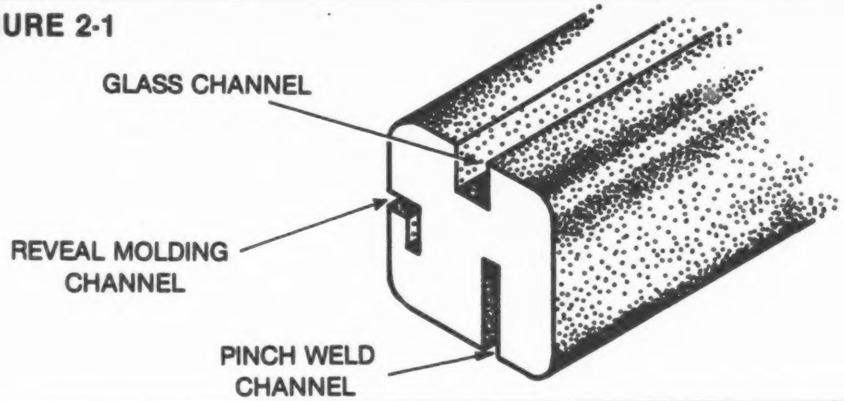
LESSON TWO: STATIONARY GLASS INSTALLATION

I. **Windshield and back glass installation techniques**

A. Gasket seal

1. Gasket is rubber weatherstripping holding glass in place.
2. Different methods of installation according to manufacturer (FIG. 2-1)

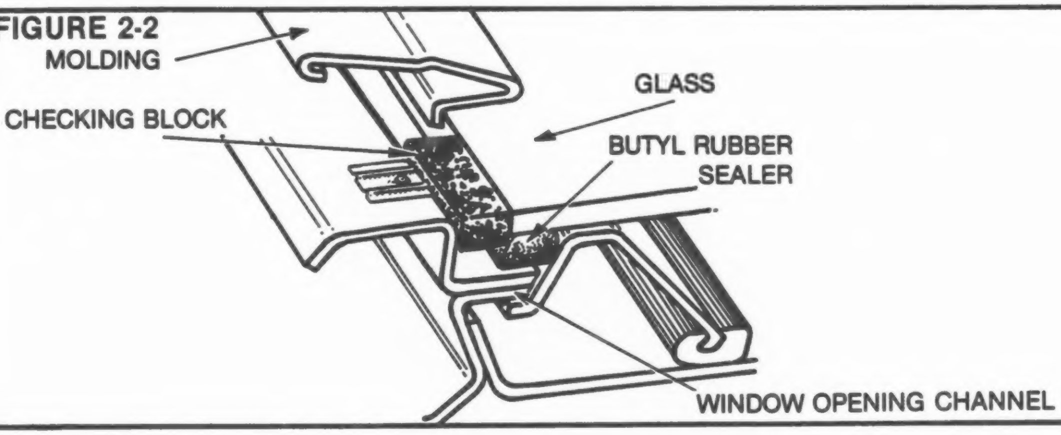
FIGURE 2-1


GLASS CHANNEL
REVEAL MOLDING CHANNEL
PINCH WELD CHANNEL

B. Butyl seal

1. Rubber strip with sealant on each side
2. Sealant bonds glass windshield to butyl and butyl to glass opening. (FIG. 2-2)

FIGURE 2-2


MOLDING
CHECKING BLOCK
GLASS
BUTYL RUBBER SEALER
WINDOW OPENING CHANNEL

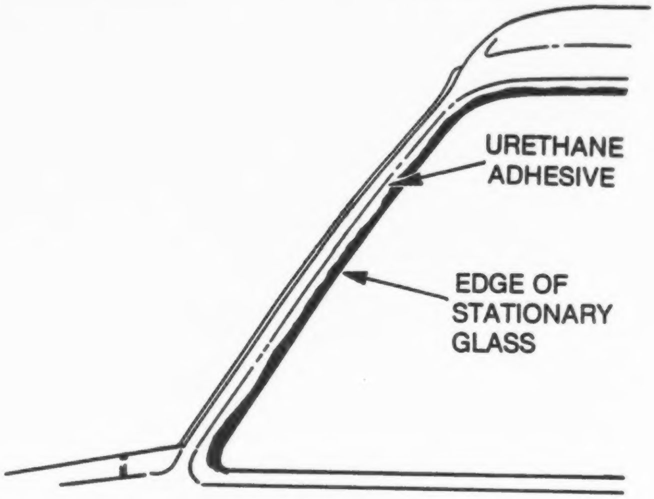
C. Urethane seal

1. Urethane is an extremely strong plastic bonding material.

2. Used on most late-model vehicles

3. Urethane bonds glass directly to glass opening. (FIG. 2-3)

FIGURE 2-3



D. Safety precautions when working with urethane

1. DO NOT work with urethane near fire or flame, including a cigarette. Urethane is extremely flammable.

2. Be careful not get urethane on any part of vehicle or yourself. It is very difficult to remove.

II. Quarter-glass installation techniques

1. Sealed permanently using variety of methods

2. Attached on hinges at front, with latch assembly allowing glass to be pushed out, acting as vent

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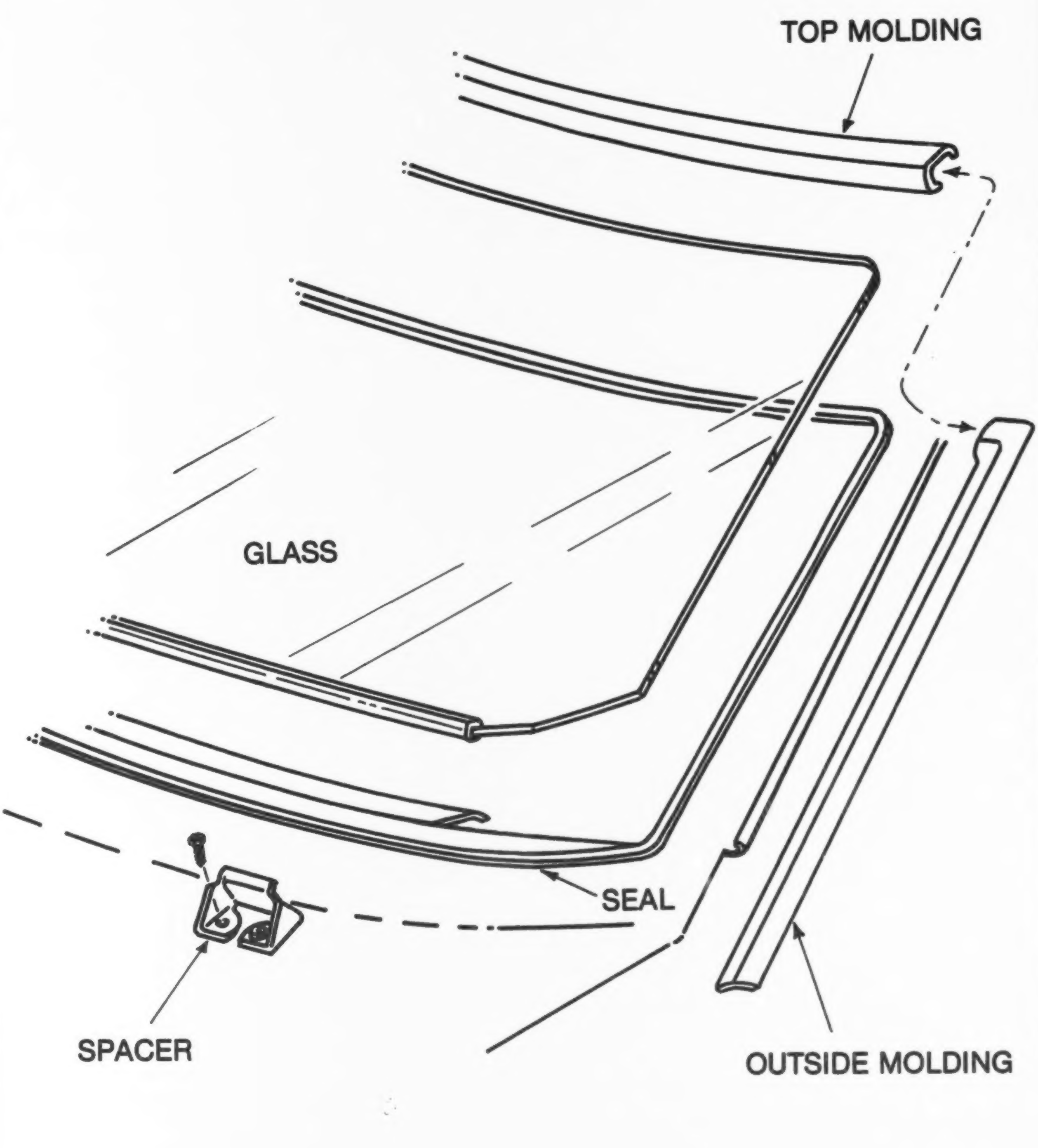
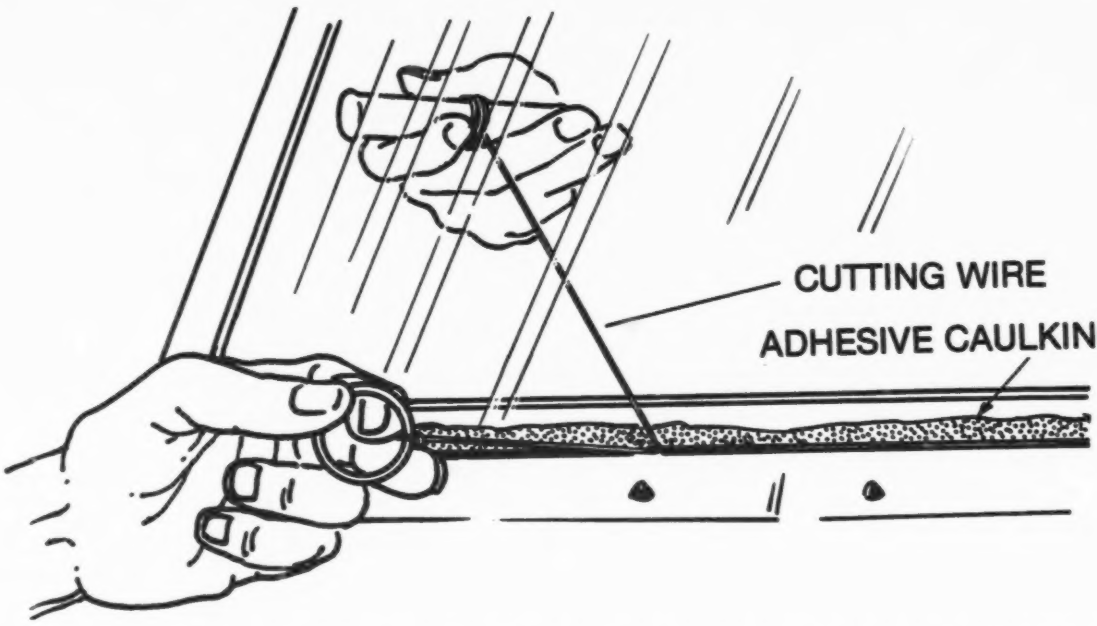
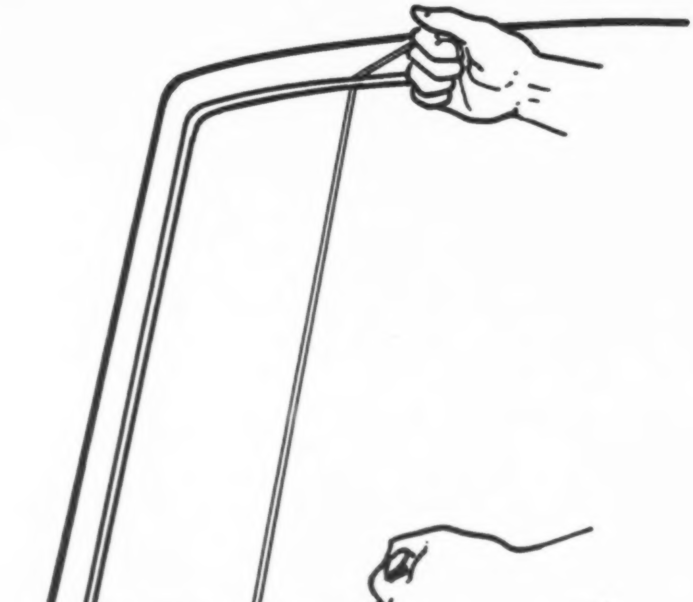
Window Removal


TOP MOLDING
GLASS
SEAL
SPACER
OUTSIDE MOLDING

Window Removal with Piano Wire

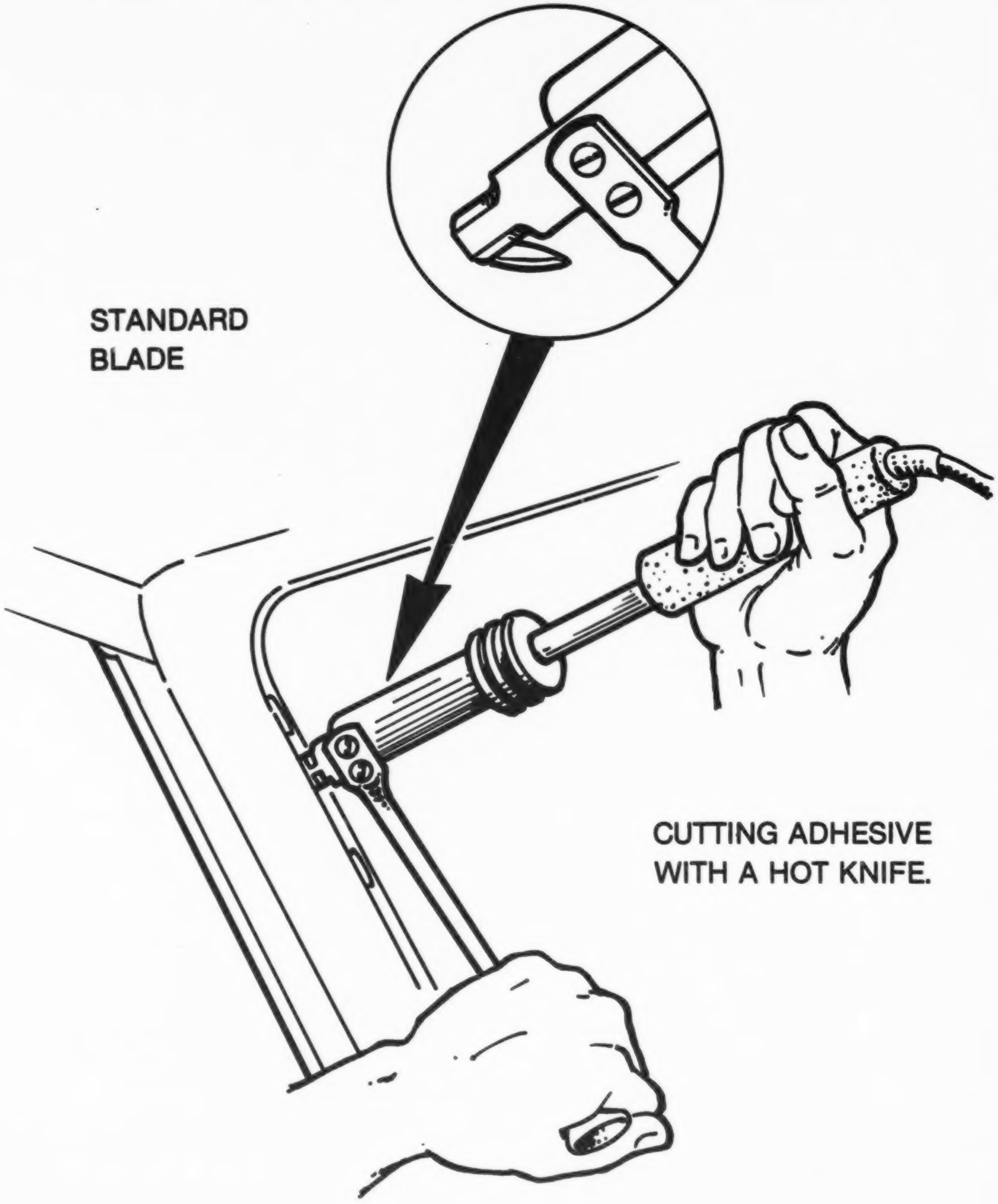

CUTTING WIRE
ADHESIVE CAULKING

USING STEEL MUSIC WIRE TO CUT THE ADHESIVE IN WHICH THE GLASS IS SET.



ONE BODY TECHNICIAN CAN CUT THE ADHESIVE FROM THE WINDSHIELD WITH MUSIC WIRE.

Window Removal by Hot Knife


STANDARD
BLADE

CUTTING ADHESIVE
WITH A HOT KNIFE.

UNIT IV

JOB SHEET #1, LESSON TWO

REMOVE AND REPLACE REVEAL MOLDING AND TRIM

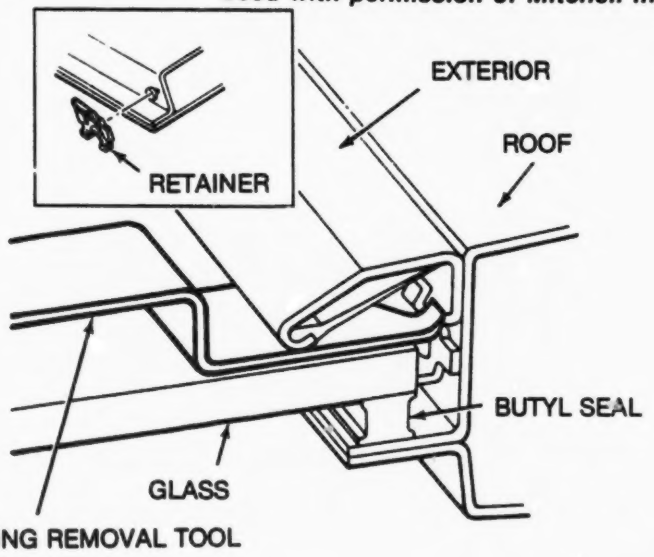
Equipment

Vehicle with metal reveal molding, front or back glass
Vehicle service manual
Replacement molding
Replacement clips
Masking tape
Caulking
Reveal molding tool
Common hand tools
Hand drill and drill bit for self-sealing screws
Trim stick
Safety glasses

Procedure:	**Evaluation:** 3	2	1	N
1. Put on safety glasses and mask adjacent finish with masking tape.				
2. Examine molding or vehicle service manual to determine method of attachment.				
3. Remove molding following service manual recommendations, using screwdriver to remove screw-attached molding and reveal molding tool to remove clip-attached molding.				

FIGURE 2-4

Used with permission of Mitchell International, Inc.



Procedure:

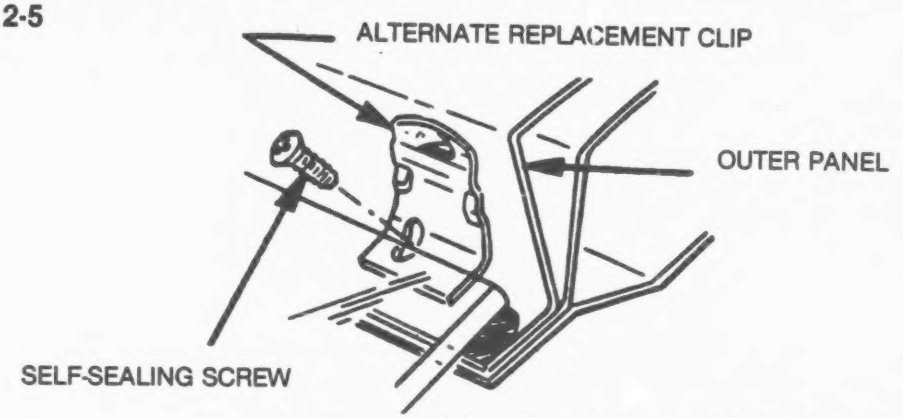
Evaluation:
3 2 1 N

4. Examine attachment clips for damage and locate replacement clips if needed. If weld on stud is damaged an alternate replacement clip must be installed by the following procedure. __ __ __ __

   A. Drill small hole next to weld-stud.

   B. Insert and tighten self-sealing screw through replacement clip.

FIGURE 2-5



General Motors Corporation, 1987, used with permission

5. After all clips are in place, replace reveal molding using one of the following procedures. __ __ __ __

   A. For screw-attached

      1. Line up molding.

      2. Install screw, self-sealing or using caulking.

   B. For clip-attached

      1. Hook molding over top of retainer clips in proper position.

      2. Rotate bottom edge into position and snap over bottom of clips, using only hand pressure.

6. Check molding for snug fit and remove tape. __ __ __ __

Average of above evaluations* __ __ __ __

(*This average is the evaluation for Competency R2 "Remove and replace a reveal molding.")

UNIT IV

JOB SHEET #2, LESSON TWO

REMOVE AND REPLACE A GASKET-TYPE WINDOW OR BACK GLASS

Equipment:

Vehicle
Vehicle service manual
Replacement glass
Common hand tools
Reveal molding tool
Trim adhesive
Pinchweld primer
Weatherstrip adhesive
Utility knife
Rope (1/4 inch, 10 feet long)
Sealing gun and sealer
Cleaning solvents
Covers for vehicle
Safety glasses

(NOTE: Installation may vary from vehicle to vehicle. Always consult vehicle service manual. If replacing back glass, two people should perform job sheet.)

Procedure:

Evaluation:
3 2 1 N

1. Cover vehicle interior and exterior and put on safety glasses. ___ ___ ___ ___
2. If removing rear window, remove wire lead to defroster, if present, following service manual procedures. ___ ___ ___ ___
3. Remove exterior and interior moldings and trim necessary to remove glass. ___ ___ ___ ___
4. Push top corner of glass from inside vehicle while working rubber off pinchweld using weatherstrip knife. ___ ___ ___ ___
5. Use gentle pressure with hands or feet to push glass out of vehicle. ___ ___ ___ ___
6. Carefully remove gasket from window, cleaning out all broken glass. ___ ___ ___ ___
7. Apply sealer inside gasket and install gasket on replacement glass, pressing until fully seated. ___ ___ ___ ___

Procedure:

Evaluation:
3 2 1 N

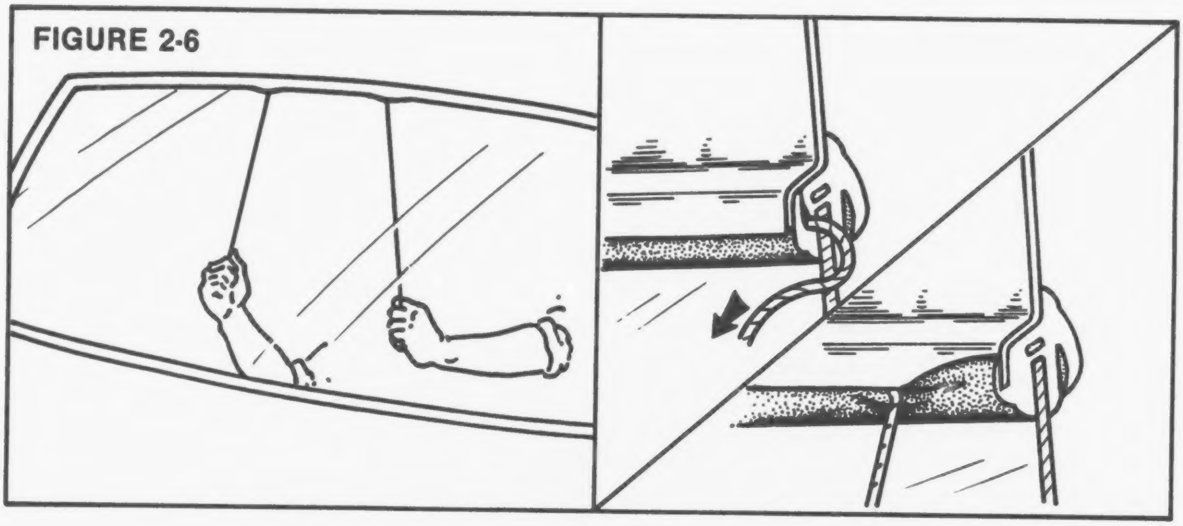
8. Use plastic knife to pry lip of molding channel outward, then slide molding into channel. ___ ___ ___ ___

9. If using rope method, install spring in pinchweld gasket. ___ ___ ___ ___

10. Position glass in glass opening and using proper glass sealer, seal around body opening. ___ ___ ___ ___

11. Seal glass by pulling pinchweld channel lip over body pinchweld by pulling string around opening. ___ ___ ___ ___

FIGURE 2-6



12. Check seat of glass in opening and using proper sealer, seal between the gasket and the glass. If using heated glass, be sure to reconnect terminals. ___ ___ ___ ___

13. Use glass clearer and razor blade to remove excess sealer from glass. ___ ___ ___ ___

14. Re-install exterior and interior molding and trim. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for Competency R3, "Remove and replace a gasket-type window or back glass.")

UNIT IV

JOB SHEET #3, LESSON TWO

REMOVE AND REPLACE GLASS WITH URETHANE SEALANTS

Equipment:

Vehicle
Vehicle service manual
Replacement glass
Common hand tools
Reveal molding tool
Trim adhesive
Pinchweld primer
Weatherstrip adhesive
Utility knife
Sealing gun and sealer
Urethane primer
Fiber paddle
Cleaning solvents
Covers for vehicle
Safety glasses

(NOTE: Installation may vary from vehicle to vehicle. Always consult vehicle service manual. Two people should perform job sheet to assist in removal and installation .)

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
1. Cover vehicle interior and exterior and put on safety glasses.				
2. Remove reveal molding.				
3. Unscrew post holding the setting blocks.				
4. Cut urethane seam with utility knife.				
(NOTE: Urethane is difficult to cut. You may have to heat the blade of the cold knife. Cut as close to windshield glass as possible.)				
5. Remove old windshield.				
6. If sealant remaining in windshield opening is uneven, smooth it with a razor blade.				
7. Re-attach setting blocks SECURELY and clean pinchweld area.				
8. Replace any damaged clips.				

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Procedure:	Evaluation: 3	2	1	N
9. Prime pinchweld with urethane primer, brushing a thin layer over the sealant remaining.	___	___	___	___
10. Rub clear glass urethane primer on edge of windshield.	___	___	___	___
(NOTE: Some urethane is primerless. If you are using primerless urethane, skip steps 9 and 10.)				
11. Use caulking gun to apply quarter-inch bead of urethane on primed pinchweld. Do not apply too low on old bead; it will ooze into the interior when windshield is set.	___	___	___	___
12. Set windshield on new bead and press into place.	___	___	___	___
13. Use fiber paddle to smooth excess from edge of windshield, filling up any cracks or crevices which may remain.	___	___	___	___
14. Spray fine mist of water over windshield edge to check seal. If leaks are detected, smooth urethane over leaking area.	___	___	___	___
15. Replace reveal molding and clean up excess urethane.	___	___	___	___
16. (Optional) Leak test windshield.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency R4, "Remove and replace glass with urethane sealants.")

UNIT IV

JOB SHEET #4, LESSON TWO

REMOVE AND RE-INSTALL GLASS WITH BUTYL TAPE KIT

Equipment:

Vehicle
Vehicle service manual
Replacement glass
Common hand tools
Reveal molding tool
Trim adhesive
Pinchweld primer
Weatherstrip adhesive
Utility knife
Banana knife
Sealing gun and sealer
Cleaning solvents
Butyl tape
Butyl primer
Butyl after-sealant
Covers for vehicle
Safety glasses

(NOTE: Installation may vary from vehicle to vehicle. Always consult vehicle service manual. Two people should perform job sheet for safe handling of front and back glass.)

Procedure:

Evaluation:
3 2 1 N

1. Cover vehicle interior and exterior and put on safety glasses. ___ ___ ___ ___

2. Remove reveal molding. ___ ___ ___ ___

3. Insert cold knife beneath edge of windshield and cut around entire perimeter. Knife can be heated moderately to help. ___ ___ ___ ___

4. If installing a painted windshield, use banana knife to cut lower seal from inside vehicle, being careful not to damage interior. ___ ___ ___ ___

5. Remove windshield. ___ ___ ___ ___

6. Scrape old sealant off pinchweld. Straighten pinchweld if needed, and repair rust. ___ ___ ___ ___

7. Check setting blocks and MAKE SURE they are completely secure. ___ ___ ___ ___

Procedure:

Evaluation:
3 2 1 N

8. Prime pinchweld with butyl primer, and prime edge of windshield with clear butyl primer. ___ ___ ___ ___

9. Replace any broken retaining clips. ___ ___ ___ ___

10. After being sure glass is clean and dry, apply butyl tape to pinchweld. ___ ___ ___ ___

    (**CAUTION:** *Touch only the protective paper.)*

11. Set windshield in place and press down to form bond. ___ ___ ___ ___

12. Apply liquid butyl after-sealant to outer perimeter of butyl tape bond. ___ ___ ___ ___

    (NOTE: If testing for leaks, air test; do not water test.)

13. Replace reveal moldings. ___ ___ ___ ___

14. Clean excess sealant. Do not wash vehicle for 24 hours. ___ ___ ___ ___

    (NOTE: The tape can be applied to the windshield first, and the windshield-with-tape set into the opening. This can make for a neater-looking job, but also leaves more room for allowing a leak.)

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for Competency R5, "Remove and replace glass with butyl tape kit.")

UNIT IV

JOB SHEET #5, LESSON TWO

INSTALL BONDED MIRROR BRACKETS TO WINDSHIELD

Equipment:

Installation kit
Masking tape
Razor blade with holder
Hand tools

(Note: The vehicle should be at least 50° F before attempting this procedure. Perform in a well-ventilated area. Make sure windshield is moisture-free.)

Procedure:	**Evaluation:** 3	2	1	N
1. Mark location of old mirror. Usually there will be residue from the old mirror bracket showing the location. Mark on the outside of the windshield, using masking tape to mark the bottom edge and one side.	___	___	___	___
2. Remove mirror from mirror mounting bracket.	___	___	___	___
3. Clean residue from windshield with razor blade in holder. If re-installing old mirror, clean residue from mounting bracket.	___	___	___	___
4. Apply cleaner-primer from kit to both windshield and mounting bracket, following kit directions. Allow to dry.	___	___	___	___
5. Take vial of adhesive and apply to mirror mounting bracket and immediately stick bracket to windshield. Use a slight twisting motion to set adhesive and then hold in proper position for about one minute.	___	___	___	___
6. Wait length of time specified in kit before installing mirror onto bracket.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency R6 "Install bonded mirror brackets to windshield.")

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT IV: GLASS

LESSON THREE: DOOR GLASS AND DOOR TRIM ASSEMBLIES

I. **Terms and Definitions**

A. Cam -- A slide block or roller that moves in a window regulator channel guide, allowing the window to be raised or lowered.

B. Center division channel -- Channel between the vent glass and door glass on vehicles with side vent windows.

C. Equalizer arm -- Channel in movable glass that allows height of window glass to be adjusted.

D. Glass run channel -- The groove in which the glass slides as it moves up and down.

E. Guides -- Various parts, used in place of glass run channel or center division channel, that control the motion of movable glass as it is raised and lowered.

F. Movable glass -- Any glass that will open and close.

G. Sash channel -- The groove used to fasten window glass to a window regulator.

H. Stabilizer strip -- Cushioning strip that prevents window from rattling when it is partially lowered.

I. Stop -- Metal, plastic or rubber devices in frameless windows, one mounted at each side of the door and one at the bottom. They keep the glass from being rolled too high or too low.

II. **Door panel interior components**

A. Door latch

B. Door lock knob

C. Door pull

D. Arm rest

E. Window regulator handle

F. Weatherstrip

G. Rear view mirror control

H. Trim panel

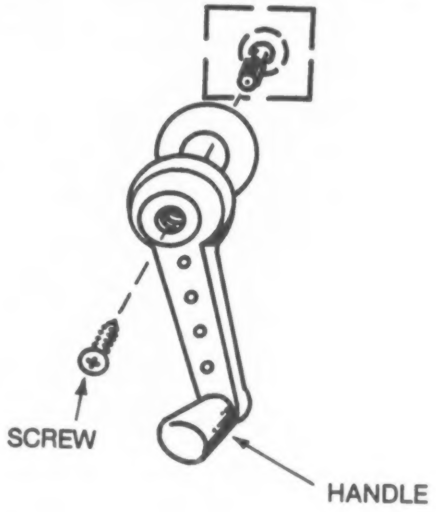
I. Water deflector

III. Methods of attaching handles (FIG. 3-1)

A. Screw-attached handle

1. Screw may be under decorative metal disc covering.
2. Metal disc covering is usually cemented on and must be gently pried off.

FIGURE 3-1

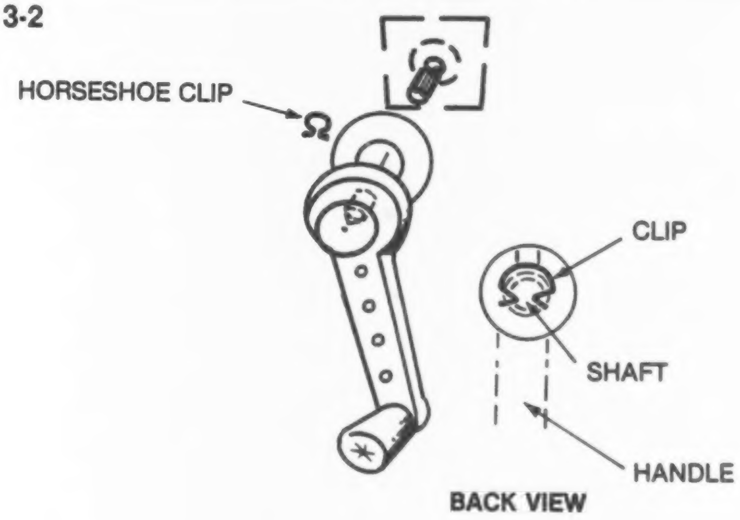


B. Clip-attached handle (FIG. 3-2)

1. Clip located between handle and escutcheon plate.

2. Special tools are needed to remove clip.

FIGURE 3-2



IV. Methods of attaching arm rest

A. Integral with trim panel, attached with screws and/or spring nuts

B. Attached with screws after trim panel

C. Attached to door panel with screws prior to trim panel

V. Principles of removing trim panel

A. All handles, and trim components not integral with the trim panel, must be removed.

B. Trim panel is fastened with trim-panel clips and must be removed with clip remover.

   1. Trim-panel clips come in a variety of styles.

   2. All clips attach into the trim panel.

   3. All clips fasten to the door panel through spring action -- "popping" into place.

C. Damaged trim-panel clips should be replaced.

D. Water deflector inside trim panel must be removed to gain access to interior components of door.

E. Water deflector should be removed carefully with putty knife.

F. In replacing water deflector, new body caulking or adhesive must be applied if needed -- deflector must seal properly.

VI. Window regulator assemblies

(Note: It is frequently necessary to replace door glass, adjust window regulators or replace regulators in auto body work.)

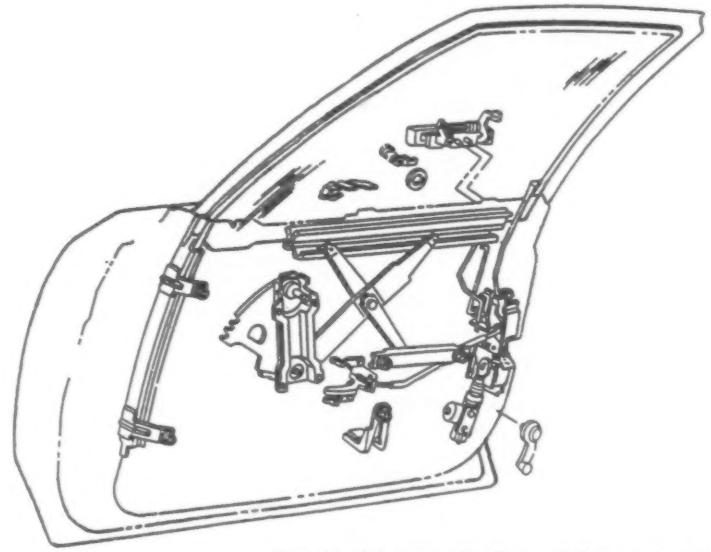
A. Typical door-glass installation techniques

1. Straight tempered glass cut to size
2. Attached to channel; channel attached to window regulator

B. Types of regulators

1. Dual U-Run (FIG. 3-3)

FIGURE 3-3



Used with permission of Mitchell International, Inc.

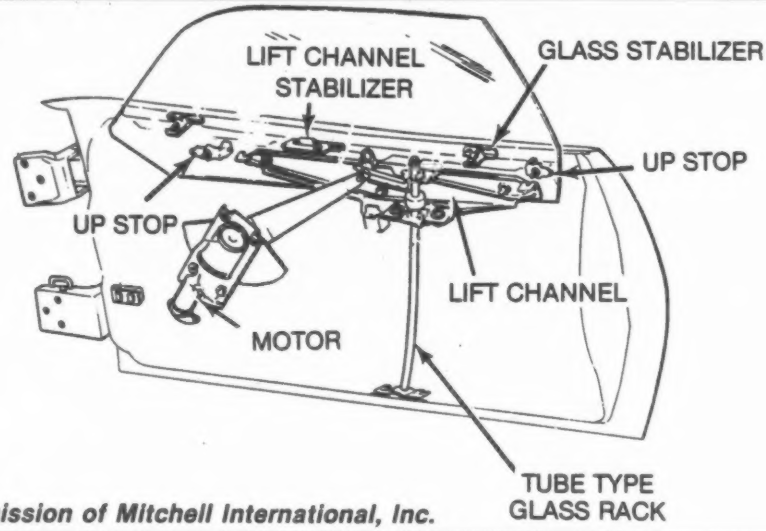
a. Window attaches to channel.

b. Roller rolls in glass channel as arm moves up and down.

c. Glass runs (vertical channels) guide glass as it rises and lowers.

2. Tube-run (FIG. 3-4)

FIGURE 3-4


LIFT CHANNEL
STABILIZER
GLASS STABILIZER
UP STOP
UP STOP
LIFT CHANNEL
MOTOR
TUBE TYPE
GLASS RACK

Used with permission of Mitchell International, Inc.

   a. Window attaches to channel

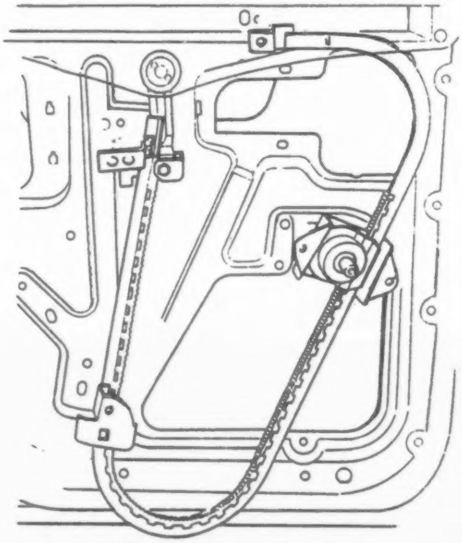
   b. Roller rolls in glass channel as arm moves up and down

   c. Tube guides glass as it is raised or lowered.

3. Flex-drive (FIG. 3-5)

FIGURE 3-5

Used with permission of Mitchell International, Inc.



MANUAL REGULATOR

a. Window bolted to end of flex drive.

b. Flex-drive belts pulls window down or pushes it up.

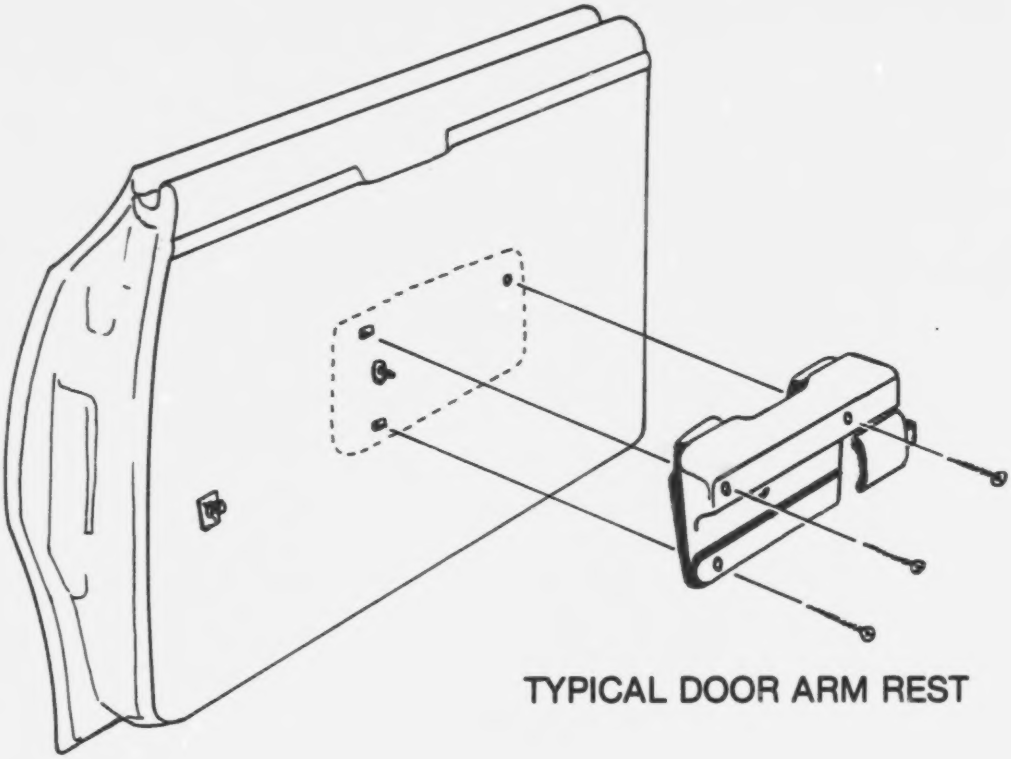
c. Rigidity of drive belt guides glass.

C. Electric window regulators

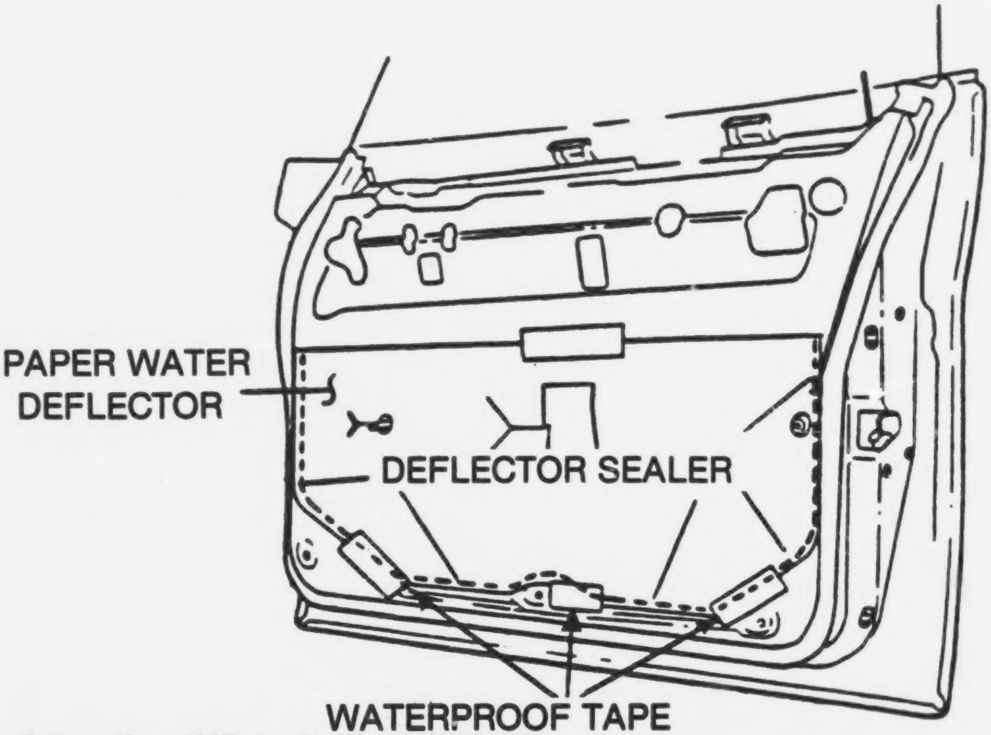
1. Very similar to manual regulators, but with electric motor driving regulator assembly.

2. Counterbalance spring on some types requires caution if removing motor from regulator. Sector gear must be locked into position. Consult vehicle service manual.

Removing Upholstery Trim and Headlinings

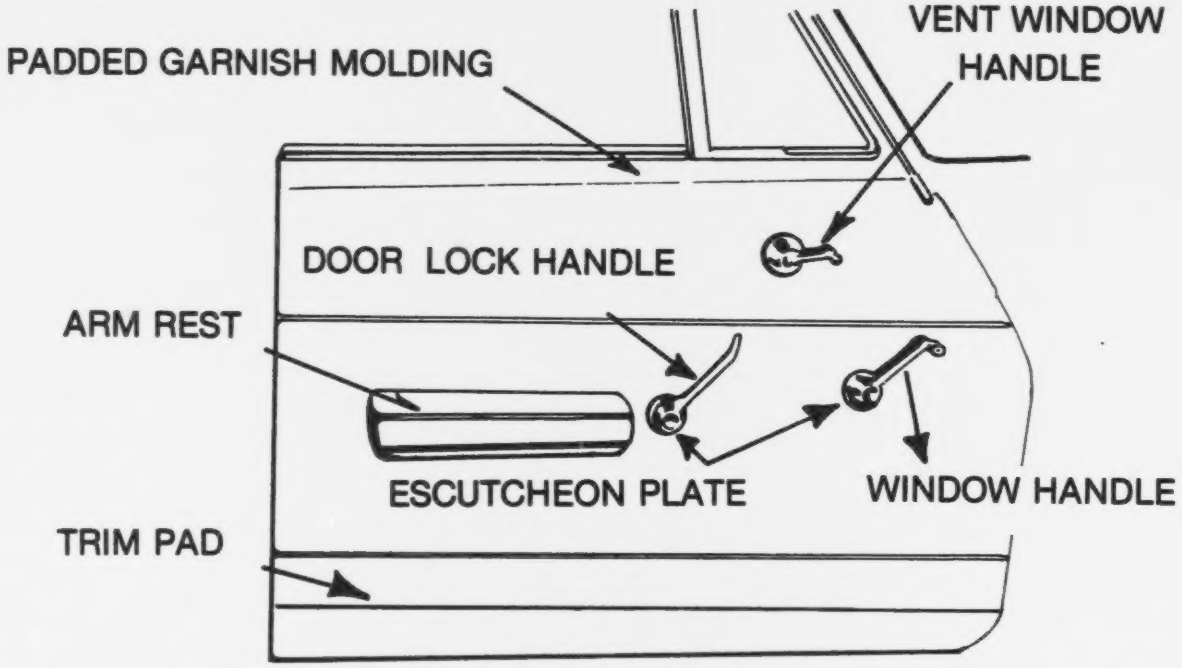


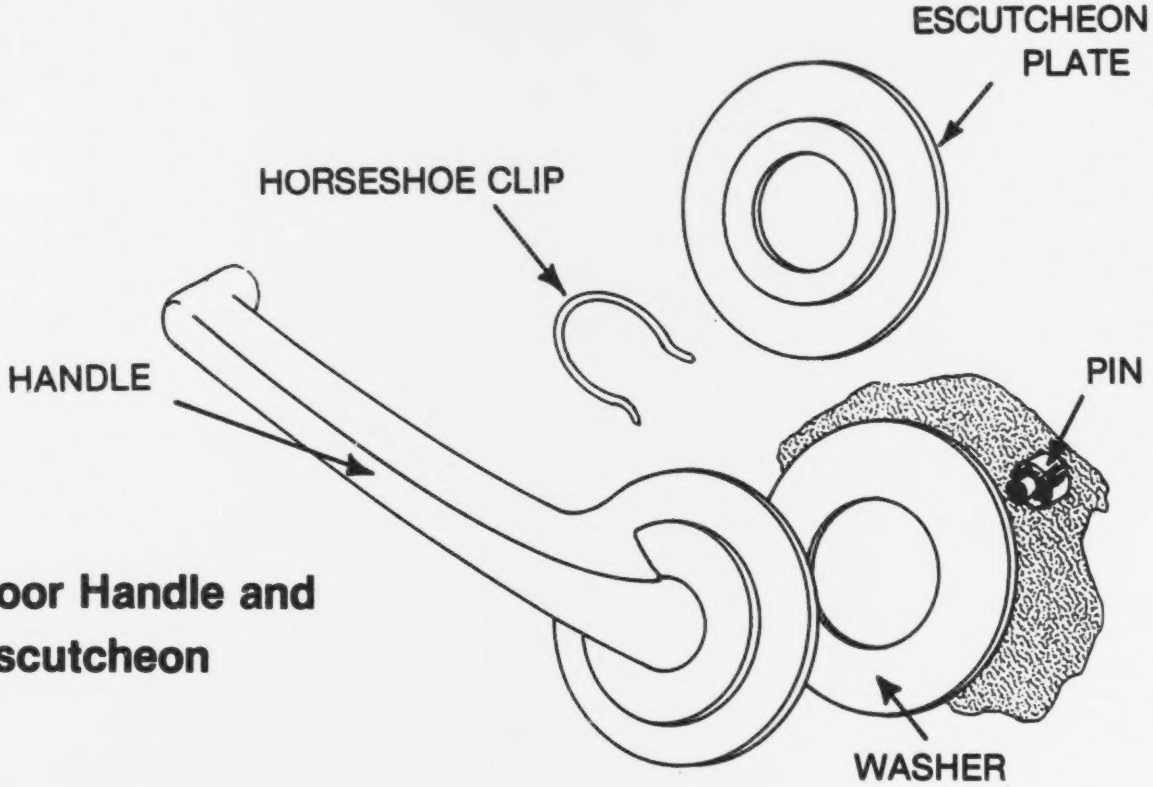
TYPICAL DOOR ARM REST


PAPER WATER DEFLECTOR
DEFLECTOR SEALER
WATERPROOF TAPE

General Motors Corporation, 1987, used with permission

Handle Arrangement on Interior Trim Pad


PADDED GARNISH MOLDING
VENT WINDOW HANDLE
DOOR LOCK HANDLE
ARM REST
ESCUTCHEON PLATE
WINDOW HANDLE
TRIM PAD


ESCUTCHEON PLATE
HORSESHOE CLIP
HANDLE
PIN
WASHER

Door Handle and Escutcheon

UNIT IV

JOB SHEET #1, LESSON THREE

REMOVE AND REPLACE A CLIP-ATTACHED DOOR HANDLE

Equipment:

Vehicle
Vehicle service manual
Covers for interior components
Door handle pliers
Door handle remover
Safety glasses

Procedure: **Evaluation:** 3 2 1 N

1. Put on safety glasses and cover interior components. Also note position of handle and replace in same position. ___ ___ ___ ___

2. Place door handle pliers or door handle remover between escutcheon plate and door handle and remove clip. ___ ___ ___ ___

3. Work off door handle by hand, or if needed, use a putty knife. Be careful not to damage door-trim panel. ___ ___ ___ ___

4. Perform additional repairs as required and then replace door handle by working slowly by hand back into position. ___ ___ ___ ___

   (NOTE: Check that handle is in proper position.)

5. Replace clip in position, using special pliers or removal tool. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average may be used as the evaluation for Competency R7 "Remove and replace a door handle.")

UNIT IV

JOB SHEET #2, LESSON THREE

REMOVE AND REPLACE A SCREW-ATTACHED DOOR HANDLE

Equipment:

Vehicle
Vehicle service manual
Covers for interior components
Appropriate screwdriver, Torx wrench or Allen wrench as required
Knife
Safety glasses

Procedure:	**Evaluation:** 3	2	1	N
1. Put on safety glasses and cover interior components. Also note position of handle and replace in same position.	___	___	___	___
2. Place knife blade carefully under decorative metal disc and pry off carefully.	___	___	___	___
3. Remove screw with appropriate tool.	___	___	___	___
4. Work off door handle by hand, or if needed, use a putty knife. Be careful not to damage door-trim panel.	___	___	___	___
5. Perform additional repairs as required and then replace door handle by working slowly by hand back into position. *(NOTE: Check that handle is in proper position.)*	___	___	___	___
6. Replace screw and replace metal disc. Consult vehicle service manual on recommended cement for replacing decorative disc.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average may be used as the evaluation for Competency R7 "Remove and replace a door handle.")

UNIT IV

JOB SHEET #3, LESSON THREE

REMOVE AND REPLACE A DOOR-TRIM PANEL

Equipment:

Vehicle
Vehicle service manual
Clip remover
Hand tools
Covers for interior components
Door handle pliers
Door handle remover
Safety glasses

(NOTE: This job sheet is for evaluation purposes only. Vehicle service manual must be consulted for exact steps of procedure.)

Procedure:	**Evaluation:** 3	2	1	N
1. Remove handles by performing Job Sheet #1 or Job Sheet #2.	___	___	___	___
2. Remove other trim components necessary for trim-panel removal.	___	___	___	___
3. Use clip remover to detach trim panel.	___	___	___	___
4. Remove water deflector carefully and perform repairs as required.	___	___	___	___
5. Replace water deflector carefully, using fresh adhesive or body caulking as required.	___	___	___	___
6. Replace damaged clips and snap trim panel back into place.	___	___	___	___
7. Replace trim components removed in step #2, above.	___	___	___	___
8. Replace handles by finishing replacement procedure in Job Sheet #1 or Job Sheet #2, as applicable.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency R8 "Remove and replace a door trim panel.")

UNIT IV

JOB SHEET #4, LESSON THREE

REMOVE AND REPLACE A LOCK CYLINDER

Equipment:

Vehicle
Vehicle service manual
Clip remover
Hand tools
Covers for interior components
Door handle pliers
Door handle remover
Safety glasses

Procedure:	**Evaluation:** 3	2	1	N
1. Raise door window glass and perform Job Sheet # 3 to remove door trim panel.	___	___	___	___
2. Slide out lock cylinder retaining clip on inside of door skin.	___	___	___	___
3. Remove lock cylinder after careful inspection of attachment to lock extension.	___	___	___	___
4. Perform other operations as required then replace lock cylinder and re-attach to lock extension.	___	___	___	___
5. Replace lock cylinder retaining clip and finish Job Sheet #3 for re-installation of trim panel.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency R9 "Remove and replace a lock cylinder.")

UNIT IV

JOB SHEET # 5, LESSON THREE

REMOVE AND REPLACE MANUAL OR ELECTRIC DOOR GLASS, CHANNEL ATTACHED

Equipment

Vehicle
Vehicle service manual
Clip remover
Hand tools
Covers for interior components
Door handle pliers
Door handle remover
Grease
Safety glasses
Additional tools as required according to vehicle service manual

(NOTE: This job sheet is for evaluation purposes only. Vehicle service manual must be consulted for exact steps of procedure.)

Procedure: **Evaluation:**
3 2 1 N

1. Remove door handles, interior trim and door panel by performing Job Sheet #3. ___ ___ ___ ___
2. If window is electric, disconnect wires to window regulator motor. ___ ___ ___ ___
3. Slide out glass channel attached to regulator arm after cleaning out all glass fragments in it. (Note whether epoxy, urethane or tape was used.) ___ ___ ___ ___
4. Temporarily re-attach door handle crank. ___ ___ ___ ___
5. Carefully place new glass in the door. ___ ___ ___ ___
6. Place glass channel back on the guides and put glass in highest position. ___ ___ ___ ___
7. Crank regulator to bottom of glass, center channel on glass and mark it. ___ ___ ___ ___
8. Lower glass and remove it, then remove the channel. ___ ___ ___ ___
9. Re-install glass on channel with epoxy, urethane or tuff-pak, as applicable. ___ ___ ___ ___

Procedure:	**Evaluation:** **3 2 1 N**
10. Re-install glass and channel back in door and check alignment.	___ ___ ___ ___
Average of above installations*	___ ___ ___ ___

(*This average may be used as is the evaluation for Competency R10 "Remove and replace door glass.")

UNIT IV

JOB SHEET #6, LESSON THREE

REMOVE AND REPLACE MANUAL OR ELECTRIC DOOR GLASS, BOLT ATTACHED

Equipment:

Vehicle
Vehicle service manual
Clip remover
Hand tools
Covers for interior components
Door handle pliers
Door handle remover
Grease
Large rivets and rivet gun (optional)
Safety glasses
Additional tools as are required according to vehicle service manual

(NOTE: This job sheet is for evaluation purposes. Vehicle service manual must be consulted for exact steps of procedure.)

Procedure: **Evaluation:**
3 2 1 N

1. Remove door handles, door trim panel and moisture barrier by performing Job Sheet #3. ___ ___ ___ ___
2. If window is electric, disconnect wires to window regulator motor. ___ ___ ___ ___
3. Remove all broken glass from the door. ___ ___ ___ ___
4. Remove the new glass from its carton and clean it thoroughly, noting hole locations. ___ ___ ___ ___
5. Put glass in door, align holes and mark them. ___ ___ ___ ___
6. Remove the new glass from door and install the plastic or metal grommets. ___ ___ ___ ___
7. Install the glass back in the door and realign the marked regulator holes. Place proper bolts or rivets through bracket and holes. (Do not tighten.) ___ ___ ___ ___
8. Install the stops and roll the window up and slowly close the door to make sure the glass is aligned properly. ___ ___ ___ ___

Procedure:	**Evaluation:** **3**	 **2**	 **1**	 **N**
9. Make any adjustments needed and tighten all nuts and bolts. Close door for final alignment check.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average may be used as is the evaluation for Competency R10 "Remove and replace door glass.")

UNIT IV

JOB SHEET #7, LESSON THREE

REMOVE AND REPLACE MANUAL OR ELECTRIC DOOR GLASS REGULATOR

Equipment

Vehicle
Vehicle service manual
Clip remover
Hand tools
Covers for interior components
Door handle pliers
Door handle remover
Grease
Large rivets and rivet gun (optional)
Safety glasses
Additional tools as are required according to vehicle service manual

(NOTE: This job sheet is for evaluation purposes only. Vehicle service manual must be consulted for exact steps of procedure.)

Procedure:	**Evaluation:** 3 2 1 N
1. Remove trim panel and window by performing Job Sheet # 5 or Job Sheet # 6 as appropriate.	__ __ __ __
2. Disconnect bolts holding in regulator, or drill out rivets, as appropriate.	__ __ __ __
(**CAUTION:** *If removal of regulator motor is required, consult vehicle service manual. The regulator lift arms in some models are under tension from the counterbalance spring and can cause serious injury if the sector gear is not locked into position. Consult service manual for procedure to lock sector gear in position.)*	
3. Slide regulator out of openings on inside of door panel.	__ __ __ __
4. Repair or replace regulator components.	__ __ __ __
5. Re-install regulator in door.	__ __ __ __

Procedure:

Evaluation:
3 2 1 N

6. Replace window and trim panel by finishing Job Sheet # 5 or #6, whichever was used. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(This average is the evaluation for Competency R11 "Remove and replace door glass regulator.")

MODULE: EXTERIOR AND INTERIOR TRIM

UNIT IV: GLASS

UNIT TEST

I. Match the terms in the left column with the most closely asscoiated definition or illustration in the right column

_____1. Banana knife

_____2. Butyl

_____3. Channel

_____4. Cold knife

_____5. Inner-shield five-ply

_____6. Lacing tool

_____7. Laminated glass

_____8. Safety glass

_____9. Setting block posts

_____10. Shaded glass

_____11. Tempered glass

_____12. Tinted glass

_____13. Urethane

_____14. Window regulator

A. Color added to glass

B. Installs locking strip

C. Strong bonding material

D. Cooled in water

E. Synthetic rubber compound

AB. Removes non-gasket windshields

AC. Two extra layers of vinyl

AD. Removes painted-bottom windshields.

AE. Either laminated or tempered

BC. Cork and rubber material

BD. Windshield sits on them

BE. Vinyl between two layers

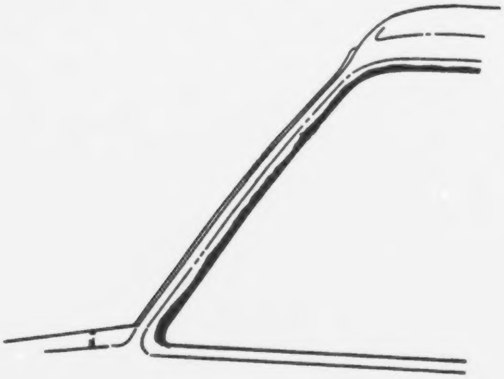
CD. Raises and lowers window

CE. Colored vinyl layer

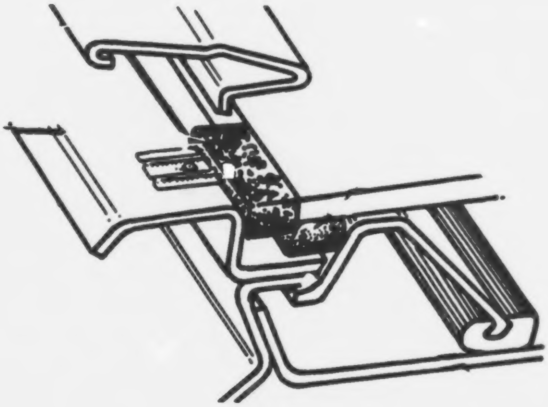
DE. U-shaped

II. Select the best answer from the choices listed.

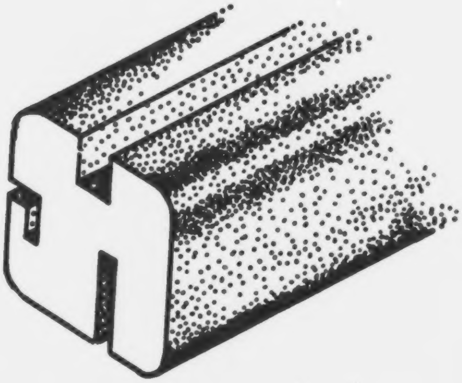
_____15. The type of windshield sealing method indicated by the illustration below is: (a) gasket seal, (b) urethane seal, (c) butyl seal, (d) PVC overlay, (e) none of the above.



_____16. The type of windshield sealing method indicated by the illustration below is: (a) gasket seal, (b) urethane seal, (c) butyl seal, (d) PVC overlay, (e) none of the above.



_____17. The type of windshield sealing method indicated by the illustration below is: (a) gasket seal, (b) urethane seal, (c) butyl seal, (d) PVC overlay, (e) none of the above.



_____18. Quarter-glass refers to glass which is: (a) in side windows, (b) in sun roofs, (c) fixed side windows, (d) in movable black glass, (e) in pickups.

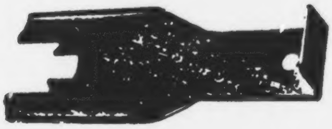
_____19. A setting block is used to: (a) hold the windshield when out of the vehicle, (b) set the height of a windshield in the opening, (c) help the adhesive bond, (d) cut out old sealant, (e) sit on while you remove a windshield.

_____20. After-sealant is used in which type of windshield installation: (a) butyl tape, (b) PVC overlay, (c) urethane, (d) gasket, (e) weatherstrip.

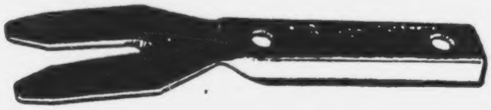
_____21. Stress cracks occur in vehicle glass due to: (a) defects in the glass, (b) a bruise, (c) improper fit, (d) too much adhesive, (e) too little adhesive.

_____22. The tool show in the illustration below is a: (a) door panel tool, (b) door handle remover, (c) reveal molding tool, (d) cold knife, (e) utility knife.

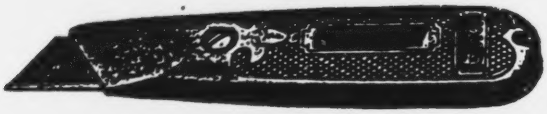
_____23. The tool shown in the illustration below is a: (a) door panel tool, (b) door handle clip tool, (c) reveal molding tool, (d) cold knife, (e) utility knife.



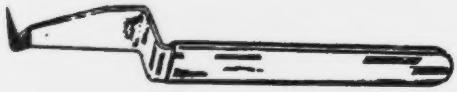
_____24. The tool shown in the illustration below is a: (a) door panel tool, (b) door handle clip tool, (c) reveal molding tool, (d) cold knife, (e) utility knife.



_____25. The tool shown in the illustration below is a: (a) door panel tool, (b) door handle clip tool, (c) reveal molding tool, (d) cold knife, (e) utility knife.



_____26. The tool shown in the illustration below is a: (a) door panel tool, (b) door handle clip tool, (c) reveal molding tool, (d) cold knife, (e) utility knife.



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III. Match the terms in the left column with the most closely asscoiated definition in the right column.

_____27. Cam

_____28. Center division channel

_____29. Equalizer arm

_____30. Glass run channel

_____31. Water deflector

_____32. Movable glass

_____33. Sash channel

_____34. Stabilizer strip

_____35. Stop

_____36. Trim panel

_____37. Dual U-run

_____38. Tube-run

_____39. Flex drive

A. Used in place of glass run channel

B. Can be raised or lowered

C. Uses vertical channels as guides

D. Uses tube as guide

E. Uses drive belt as guide

AB. Slide block or roller

AC. Groove to fastener glass to regulator

AD. Between vent glass and door glass

AE. Channel allowing height adjustment

BC. Keeps glass from being rolled too high or low

BD. Prevents rattling

BE. Groove in which glass slides

CD. Must seal properly

CE. Fastened with clips to inside of door

(NOTE: Completion of this test with a minimum score of _____ percent is necessary for the student to receive evaluations for any of the job sheets in Unit IV. It is also the evaluation for Competency R1 "Identify vehicle glass and replacement procedures." Of the 39 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, the student should retake this test.)

ANSWERS TO UNIT IV TEST

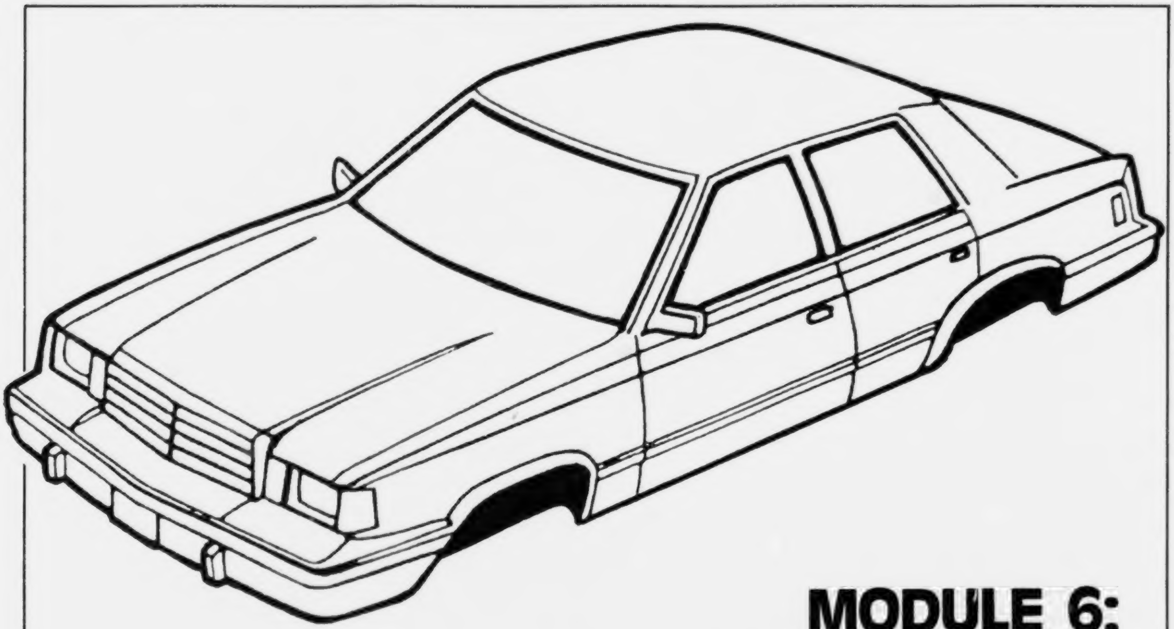
1. AD
2. E
3. DE
4. AB
5. AC
6. B
7. BE
8. AE
9. BD
10. CE
11. D
12. A
13. C
14. CD

15. B
16. C
17. A
18. C
19. B
20. A
21. C
22. D
23. B
24. A
25. E
26. C

27. AB
28. AD
29. AE
30. BE
31. CD
32. B
33. AC
34. BD
35. BC
36. CE
37. C
38. D
39. E

Auto Body Repair Curriculum Guide

INSTRUCTOR'S GUIDE



MODULE 6:

- Electrical Systems
- Lighting Systems
- Engine Cooling Systems
- Air Conditioning
- Safety

Mechanical Services

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Cover illustration courtesy of Chrysler Motors

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AUTO BODY CURRICULUM
Instructor's guide

MODULE 6:
MECHANICAL SERVICES

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University of Missouri-Columbia
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314/882-2884
July 1988

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Unit I: **Electrical systems** **1**

Unit II: **Engine cooling systems** **63**

Unit III: **Air Conditioning systems** **127**

Auto Body

Mechanical Services

Cross-Reference Table of Instructional Materials

Competency	Unit	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
S 1	I	1-I		1-4			1-49	
		2-I--2-III		1-4				
S 2	I	1-I--1-III		1-4		1	1-49	
S 3	I	2-I--2-III		1-4		1-3	1-49	
T 1	I	3-II				3	1-49	
T 2	I	3-I				1	1-49	
T 3	I	3-III				4	1-49	
T 4	I	3-IVb				2		
U 1	II	1-I--1-III		1-3			1-36	
		2-I		1-3		1		
U 2	II	1-I--1-IV		4		2	1-36	
U 3	II	3-IV				3	1-36	
U 4	II	3-I--3-III		1-2		1-2	1-36	
U 5	II	1-I--1-IV		3		1	1-36	
V 1	III	1-I--1-VI		3			1-32	
		2-I--2-III		6				
V 2	III	2-IVc				3	1-32	
V 3	III	2-IVd				4	1-32	
V 4	III	2-IVa				1	1-32	
V 5	III	2-IVe				5	1-32	
V 6	III	2-IVb				2	1-32	
V 7	III	2-IVf				5	1-32	

MODULE: MECHANICAL SERVICES

UNIT I: ELECTRICAL SYSTEMS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify the components of vehicle electrical systems and service the components of electrical systems. Mastery will be evidenced though demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Match terms with their definitions or illustrations (Competency S1, Unit I test)

II. Identify proper methods of servicing a battery (Competency S2, Unit I test)

III. Identify first aid for electrolyte contact (Competency S2, Unit I test)

IV. Demonstrate the ability to service a battery (Competency S2, JS#1)

Lesson 2:

I. Match terms with their definitions (Competency S1, Unit I test)

II. Identify principles of electrical systems (Competency S1. Unit I test)

III. Identify safety procedures (Competency S1, Unit I test)

IV. Demonstrate ability to:

  a. Install a soldered terminal (Competency S3, JS#1)

  b. Install a solderless terminal (Competency S3, JS#2)

  c. Splice a wire, soldered and solderless (Competency S3, JS#3)

Lesson 3:

I. Identify headlight assemblies (Competency T2, Unit I test)

II. Identify taillight assemblies (Competency T1, Unit I test)

III. Identify mechanical headlight assemblies (Competency T3, Unit I test)

IV. Demonstrate the ability to:

  a. Service a headlight assembly Competency T2, JS#1)

  b. Aim headlights using mechanical aiming equipment Competency T4, JS#2)

  c. Service a taillight assembly (Competency T1, JS#3)

  d. Service mechanical headlights and covers (Competency T3, JS#4)

MODULE: MECHANICAL SERVICES

UNIT I: ELECTRICAL SYSTEMS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Notes to the instructor

C. References

D. Lesson plans

1. Lesson 1: The Battery

    a. Information outline

    b. Handouts

        HO#1: Battery visual checks
        HO#2: Battery specific gravity
        HO#3: Temperature-corrected hydrometer
        HO#4: Battery tests

    c. Job sheets

        JS#1: Service a battery

2. Lesson 2: Principles of Electrical Systems

    a. Information outline

    b. Handouts

        HO#1: Typical automotive circuit
        HO#2: Typical automotive circuit
        HO#3: Typical signal light wiring diagram
        HO#4: Typical engine-compartment wiring diagram

    c. Job sheets

        JS#1: Install a soldered terminal
        JS#2: Install a solderless terminal
        JS#3: Splice a wire

3. Lesson 3: Lighting Systems

    a. Information outline

    b. Job sheets

        JS#1: Service headlights
        JS#2: Aim headlights
        JS#3: Service taillight assembly
        JS#4: Service mechanical headlights and covers

E. Unit test

F. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Due to this unit receiving a low priority, the information presented is not as thorough as in the bulk of the material in this curriculum. For that reason, supplemental material will have to be used for students to gain a better understanding. The units in this module are not as suitable as material in the other modules for independent study by the student.

REFERENCES USED IN WRITING THIS UNIT

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2. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

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11. Toboldt, William K., and Johnson, Larry. *Automotive Encyclopedia.* Sixth edition. Goodheart-Willcox. South Holland, IL. 1979.

MODULE: MECHANICAL SERVICES

UNIT I: ELECTRICAL SYSTEMS

LESSON 1: THE BATTERY

I. **Terms and definitions**

A. Amperage -- A measure of the strength of current flowing through a circuit.

B. Battery -- Produces electric current for vehicle by chemical reaction, including power source for cranking system.

(NOTE: Batteries do not store electricity, they produce it.)

C. Circuit -- The path that electricity follows in flowing from positive polarity to negative polarity. In a vehicle it consists of the battery, wiring, electrical devices, and vehicle frame and metal body.

D. Ground -- Any electrical connection in which a negative polarity connection is attached to something capable of absorbing current flow. In the case of a vehicle ground connections are usually made to the frame or engine block. The negative battery terminal is usually grounded.

E. Terminal -- A post made of lead that is part of the battery and carries the electrical charge between the battery cells and the battery cable.

(NOTE: Batteries contain two terminals, one positive {+} and one negative {-}. The terminals are located either on the top or the side of the battery. On a side-terminal battery, the bolt and thread sizes of the positive terminal are greater than those of the negative terminal. On batteries with top-terminals, the positive terminal is larger than the negative terminal.)

F. Voltage -- A measure of the amount of pressure that pushes or forces current through a circuit.

II. **Battery service**

(NOTE: Proper operation of the battery is dependent upon the condition of the electrolyte. A number of tests can be performed on the battery to find out its condition. These tests are necessary to determine if a battery should be kept in service or if it should be replaced. Safety must be observed when working with the battery and the test instruments, because severe injury and burns could result from carelessness).

A. Visual battery checks (See HO #1.)

1. Loose hold-down
2. Dirt
3. Overfilling
4. Corrosion
5. Frayed or broken cables

6. Sealing compound defect
7. Cracked case
8. Low electrolyte
9. Cracked cell cover
10. Cell connector corrosion

B. Methods of testing batteries

1. Specific gravity test (See HO #2 and #3.)
2. Battery voltage
3. Battery rating
4. Load test (See HO #4.)
5. Cadmium test (if applicable)
6. Three-minute charge test (See HO #4.)

C. Methods of charging a battery

1. Slow charging - Passing of a relatively small amount (5 to 7 amps) of current through a battery for a fairly long period (14 to 16 hours or longer).
2. Fast charging - Sending a relatively heavy initial current (50 to 60 amps for 12-volt batteries) through a battery in a short time (1 to 2 hours).
3. Automotive charging system

D. Procedures for servicing batteries

1. Clean battery case.
2. Adjust electrolyte level.
3. Clean battery terminals and cables.

E. The battery on computer-controlled cars.

1. The battery must be disconnected properly on vehicles with on-board computers.
2. Improper disconnection may damage the computers. Always consult vehicle manufacturer's recommendations.

III. First aid for electrolyte contact

A. Eye Contact

1. Immediately flush with water for at least 15 minutes.

2. Seek medical attention immediately.

3. If medical assistance is not available, neutralize acid with baking soda and water solution (2 tablespoons baking soda in 2 cups of water).

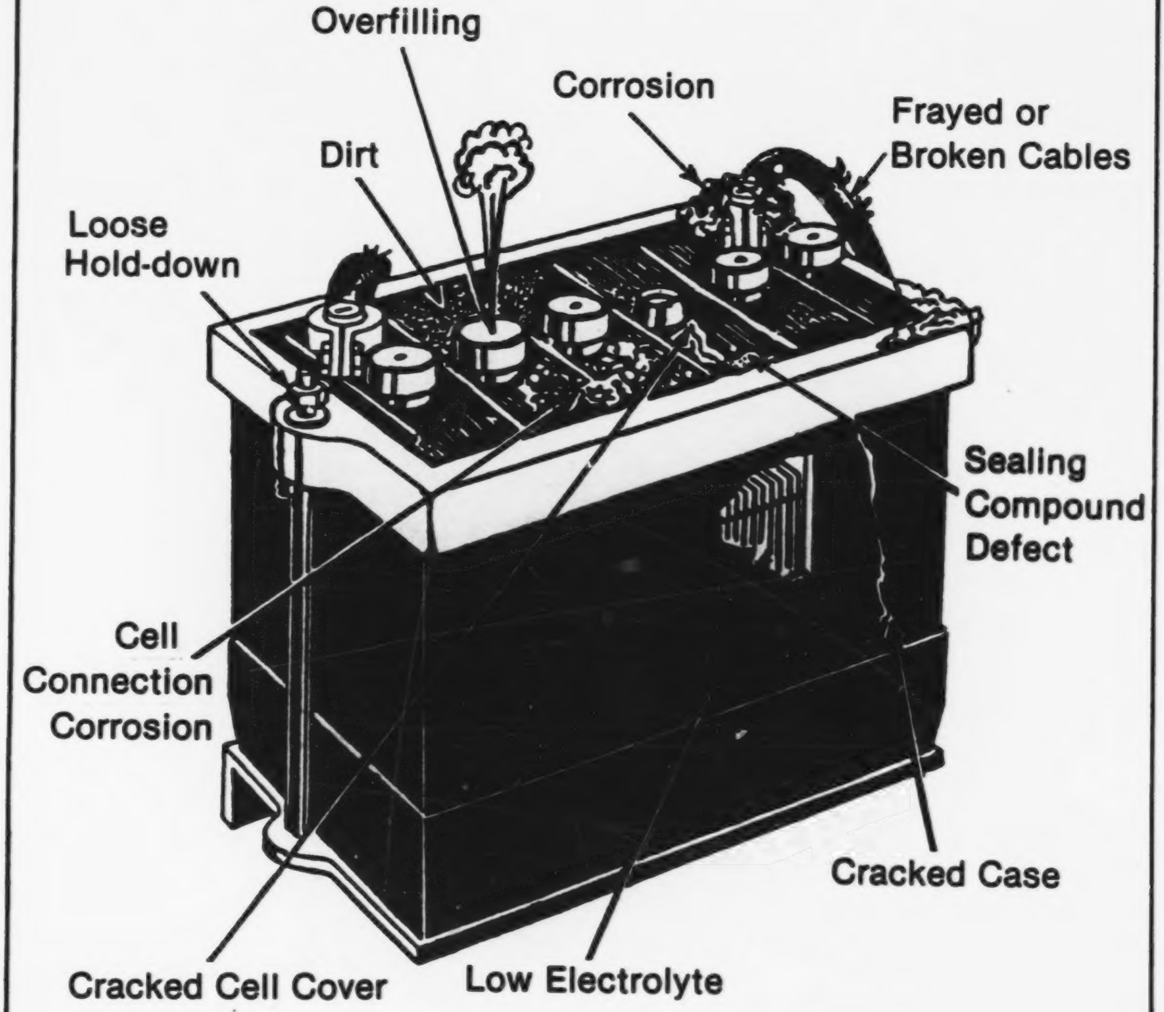
B. Skin Contact

1. Remove clothing from affected area.

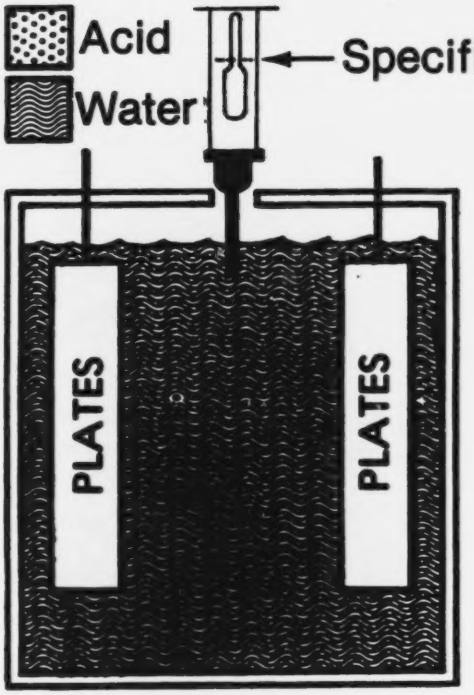
2. Wash area with plenty of soap and water for at least five minutes.

3. Seek medical attention if blistering, burning, or peeling occurs.

Battery Visual Checks

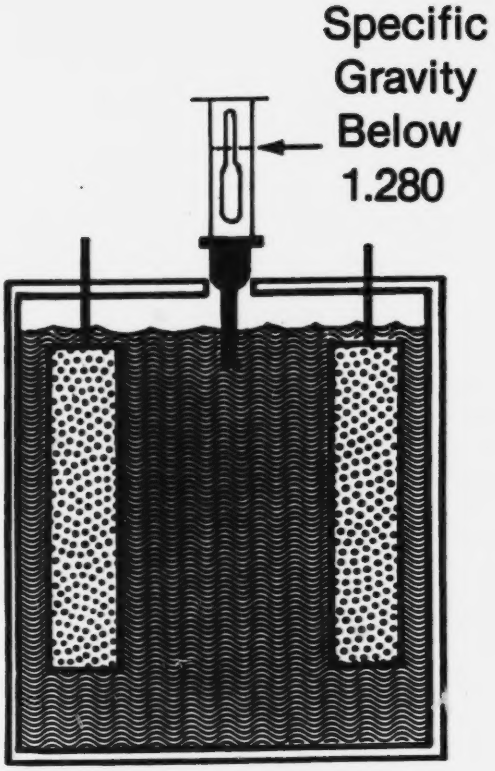

Overfilling
Corrosion
Frayed or Broken Cables
Dirt
Loose Hold-down
Sealing Compound Defect
Cell Connection Corrosion
Cracked Case
Cracked Cell Cover
Low Electrolyte

Battery Specific Gravity


Acid
Water
Specific Gravity 1.280
PLATES
PLATES

Fully Charged

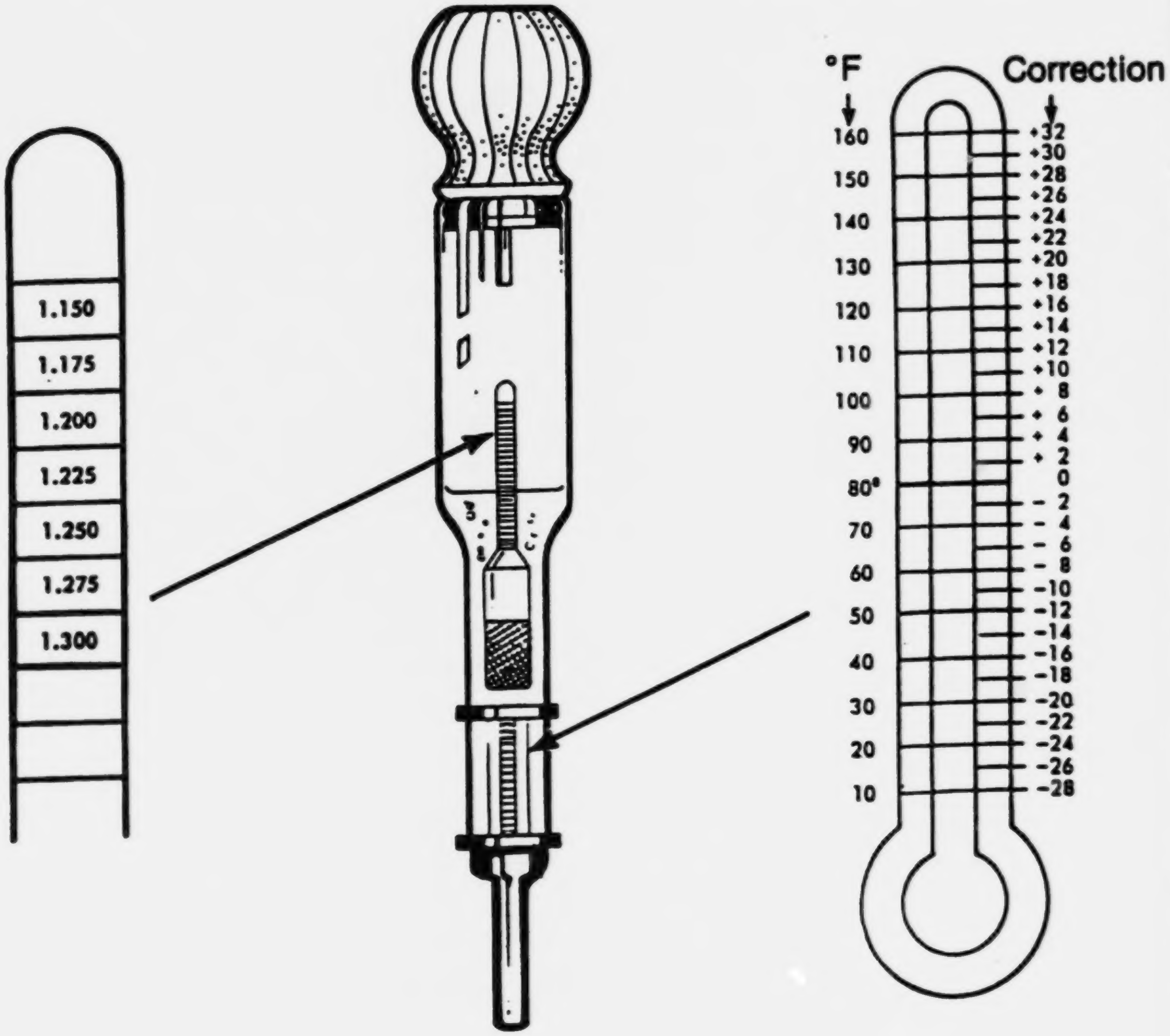
Acid in water gives electrolyte specific gravity of 1.280.


Specific Gravity Below 1.280

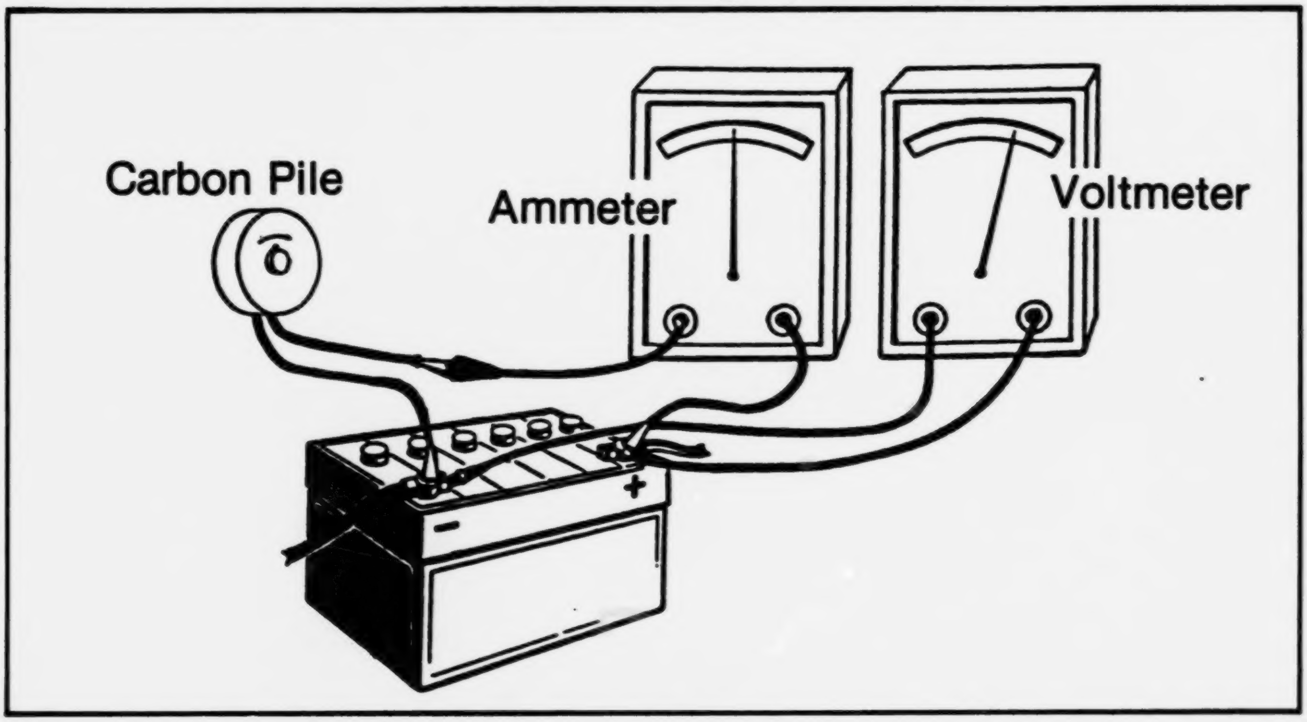
Going Down

As the battery discharges, acid begins to lodge in the plates. Specific gravity drops.

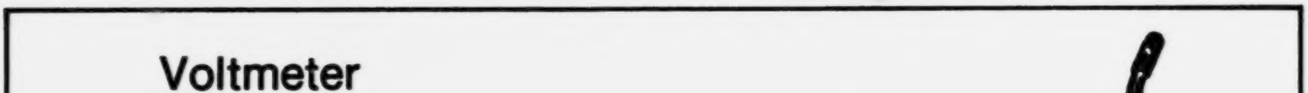
Temperature Corrected Hydrometer


1.150
1.175
1.200
1.225
1.250
1.275
1.300
°F
Correction
160
150
140
130
120
110
100
90
80°
70
60
50
40
30
20
10
+32
+30
+28
+26
+24
+22
+20
+18
+16
+14
+12
+10
+ 8
+ 6
+ 4
+ 2
0
– 2
– 4
– 6
– 8
–10
–12
–14
–16
–18
–20
–22
–24
–26
–28

Battery Capacity (Load) Test


Carbon Pile
Ammeter
Voltmeter
+
−

Three Minute Charge Test


Voltmeter
Fast
BATTERY CHARGER
+
−

UNIT V

JOB SHEET #1, LESSON ONE

SERVICE A BATTERY

Equipment:

Hydrometer
Battery charger
Cadmium-tip tester
Water
Battery load tester
Baking soda
Full face shield
Rubber gloves
Rubber apron
Bristle brush
Wire brush
Screwdriver
Battery clamp puller
Shop towels
Combination end wrenches, 7/16" - 9/16" (11 mm - 15 mm)
Baking soda and water solution (two tablespoons of baking soda to one pint of water)
Battery anti-corrosion paste

(NOTE: The steps of procedure are for the student's benefit and not for evaluation purposes. At the end of the job sheet is a product evaluation for the competency.)

Operation #1: Testing specific gravity of a battery

Procedure:

1. Remove vent covers.

2. Compress bulb of hydrometer.

3. Insert tip of hydrometer into electrolyte of one cell.

4. Release bulb and draw some electrolyte into the body of the hydrometer.

   (**CAUTION:** *Do not lift the hydrometer from the cell. Spilled electrolyte (acid) may burn skin and clothing.)*

5. Read float level and temperature of electrolyte.

   (NOTE: Bend down so that the level of the electrolyte is at eye level when reading the specific gravity.)

6. Return all of the electrolyte to the cell.

Procedure:

7. Record reading and make temperature-corrected float readings.

8. Repeat test for all cells. A difference in 25 (.025) points usually indicates a battery is starting to fail.

9. Adjust electrolyte level if necessary (add water only).

10. If readings are all above 1.225 specific gravity, make load test. If below, first charge battery; then make load test.

(**CAUTION:** *Never add water before charging except to cover exposed plates.)*

Operation #2: Testing capacity (load)

Procedure:

1. Connect tester as directed.

(**CAUTION:** *Carbon pile load switch should be off to prevent sparks when attaching cables.)*

2. Connect ammeter and voltmeter as directed.

3. Calculate the battery amp-hour rating.

4. Apply a load, by means of the carbon pile, on the battery, equivalent to three times the battery amp-hour rating.

5. Keep the above load on for 15 seconds.

6. At the end of 15 seconds a voltmeter reading of 9.5 volts or more (4.8 for 6-volt batteries) indicates a good battery.

(NOTE: Another method of testing battery capacity is to load the battery to one half of the cold amp rating for 15 seconds. Voltmeter reading should be the same as in step 5, above.)

897

Operation #3: Cadmium-tip testing

Procedure:

1. If the battery has been charged during the last eight hours, turn the headlights on for one minute.
2. Remove the cell covers.
3. Place RED probe into cell next to the + (positive) terminal and the BLACK probe into the adjacent cell.
4. Record the meter reading.
5. Move probes to cell two and cell three.
6. Repeat this procedure for all cells.
7. If any two cells vary more than five scale divisions, the battery is near failure.

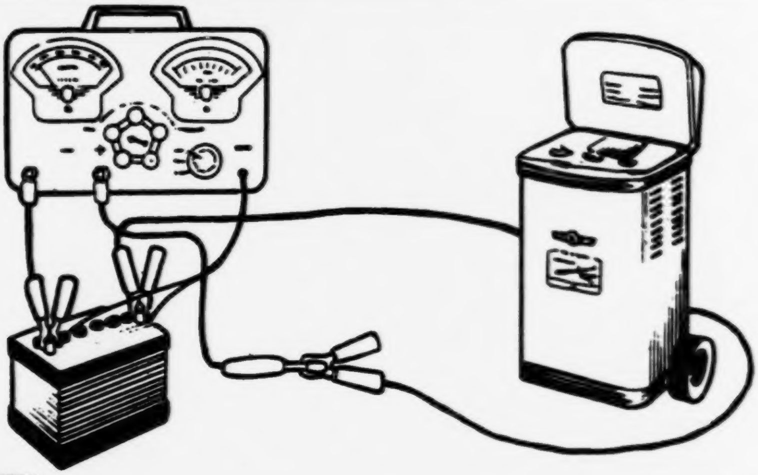
Operation #4: Charge testing battery (optional)

(NOTE: This test cannot be performed on service-free batteries because the individual cells cannot be checked. However, it should be used on conventional batteries that fail the capacity test.)

Procedure:

1. Connect tester and charger. (Figure 1-1.)

FIGURE 1-1



2. Turn charger on and adjust the charging rate to 40 amps.

Procedure:

3. Charge battery for three minutes.

4. Read individual cell voltages with battery still in operation.

   (NOTE: If they vary by more than 0.1-volt, replace the battery.)

5. Read total battery voltage.

   (NOTE: If it is above 15.5 volts, the battery is unsatisfactory and must be given a long, slow charge and load tested again. If voltage under load test is less than 9.6 volts, replace battery.)

Operation #5: Clean the battery

Procedure:

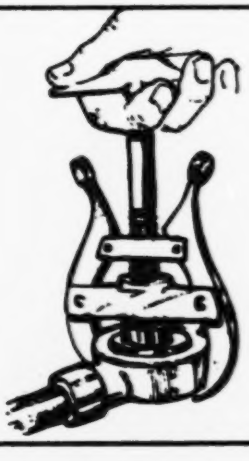
1. Disconnect battery cables from the battery posts.

   (NOTE: Always disconnect the grounded battery cable first to avoid short circuits. Use care to avoid twisting the cable post).

2. Pry clamp open.

3. Pull cable off. (Figure 1-2).

FIGURE 1-2

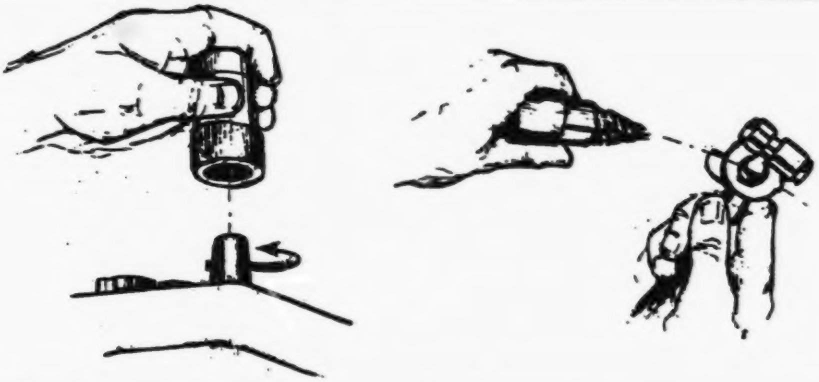


Procedure:

4. Clean cable clamps and post. (Figure 1-3).

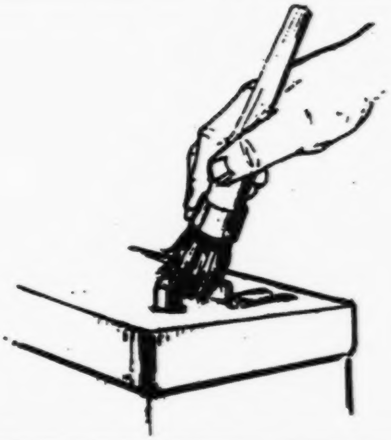
   (NOTE: Battery posts and inside of battery cable clamps must be clean and bright.)

FIGURE 1-3



5. Remove loose dirt and corrosion particles from top of battery. (Figure 1-4.)

FIGURE 1-4



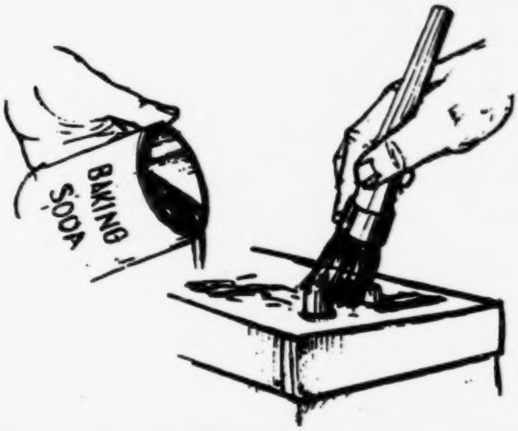
900

Procedure:

6. Brush soda-water solution on battery, battery post, clamps, and battery hold-down. (Figure 1-5.) — — — —

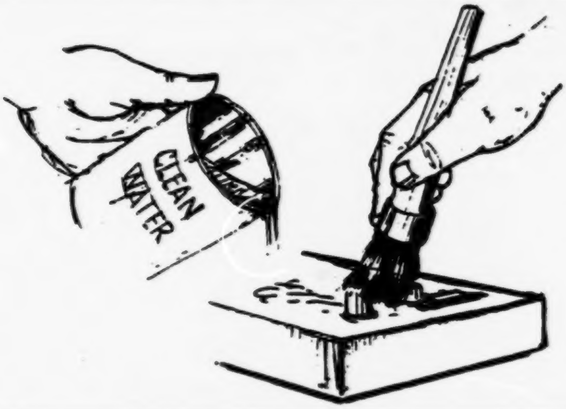
   (NOTE: Keep water and soda from entering the battery through the vent holes in the vent caps.)

FIGURE 1-5



7. Wash away residue with clean water. (Figure 1-6.)

FIGURE 1-6



8. Dry the battery and battery cables with a clean cloth.

9. Reconnect battery cables to the battery posts.

   (CAUTION: *Always reconnect the power cable first and the ground cable last.)*

Procedure:

10. Spread a coating of battery anti-corrosion paste over the cable clamps and terminals.

11. Remove vent caps.

12. Check electrolyte level in all cells, if possible.

13. Add water if necessary to bring electrolyte up to proper level.

    (NOTE: Do not overfill.)

EVALUATION FOR JOB SHEET #1

Operation:	**Evaluation:** 3	2	1	N
#1: Correctly recorded temperature-adjusted float readings from hydrometer for all six cells.	___	___	___	___
#2: Correctly tested capacity of battery.	___	___	___	___
#3: Recorded cadmium tip test readings accurately.	___	___	___	___
#4: (Optional) Successfully charge tested battery.	___	___	___	___
#5: Cleaned battery and battery components.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency S2 "Service a Battery.")

MODULE: MECHANICAL SERVICES

UNIT I: ELECTRICAL SYSTEMS

LESSON 2: PRINCIPLES OF ELECTRICAL SYSTEMS

I. **Terms and definitions**

A. Alternating current (AC) – Electrical system in which the flow of electrons in a conductor reverses direction of flow at intervals.

B. Alternator – Any electric generator that produces alternating current.

C. Cable – Heavy-duty conductors, usually associated with the conductors leading directly from the battery terminal posts.

D. Circuit – A continuous path through a conducting material in which an electrical current can flow from a power source, through a load, and back to the source.

E. Circuit breaker – A mechanical device activated by heat. When amperage produces heat in excess of the circuit's safety rating, a set of contact points opens and stops current flow.

F. Condenser (capacitor) – A device in an electrical circuit using contact points that open and close. The condenser stores current to prevent arcing and burning when the contact points are open.

G. Conductor – Any material that allows electrical current to flow through it easily.

H. Connector (terminal) – Any device used to attach electrical circuit components together.

I. Direct current (DC) – Electrical system in which a steady flow of electrons moves continually in the same direction along a conductor.

J. Fuse – A device designed to break the circuit during an excessive amount of current flow. Usually a glass tube with metal ends connected by a metal strip. The metal strip melts at excessive current.

(NOTE: Fuses are rated in amperes and the recommended amperage rating must be followed. DO NOT install a fuse with a higher amperage rating than that recommended by the manufacturer.)

K. Generator – Electric generator producing direct current.

L. Grounded circuit – A circuit in which the current is flowing to a ground instead of through the circuit.

M. Insulator – Any material that prevents the flow of electrical current. Insulators surround conductors to prevent current from shorting to another conductor.

N. Junction block – A point in a circuit for multiple connection points for current or ground.

O. Load – Any device that converts electrical energy into heat, light, or mechanical energy.

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P. Open circuit – A circuit in which a conductor is broken or disconnected and current is unable to flow.

Q. Primary wire – A low-tension conductor used for low-voltage circuits. Primary wires are measured in gauge number. The higher the gauge number, the smaller the wire.

R. Secondary wire -- A high-tension conductor used for high-voltage circuits.

S. Short circuit – A problem in an electrical circuit in which a conductor touches another conductor and provides another path for current flow. Normally when a circuit shorts, excessive current flows, resulting in a blown fuse or the activation of a circuit breaker.

T. Switch -- Any device that can open or close a circuit.

U. Wiring diagram (schematic) – A drawing that uses electrical symbols to show the path of an electrical circuit.

V. Wiring harness – A system of wires which is formed into a unit so that many wires to many devices are routed together.

II. **Principles of electrical systems**

A. Electrical systems are often damaged in a collision.

B. Operations which a body shop technician must be able to perform

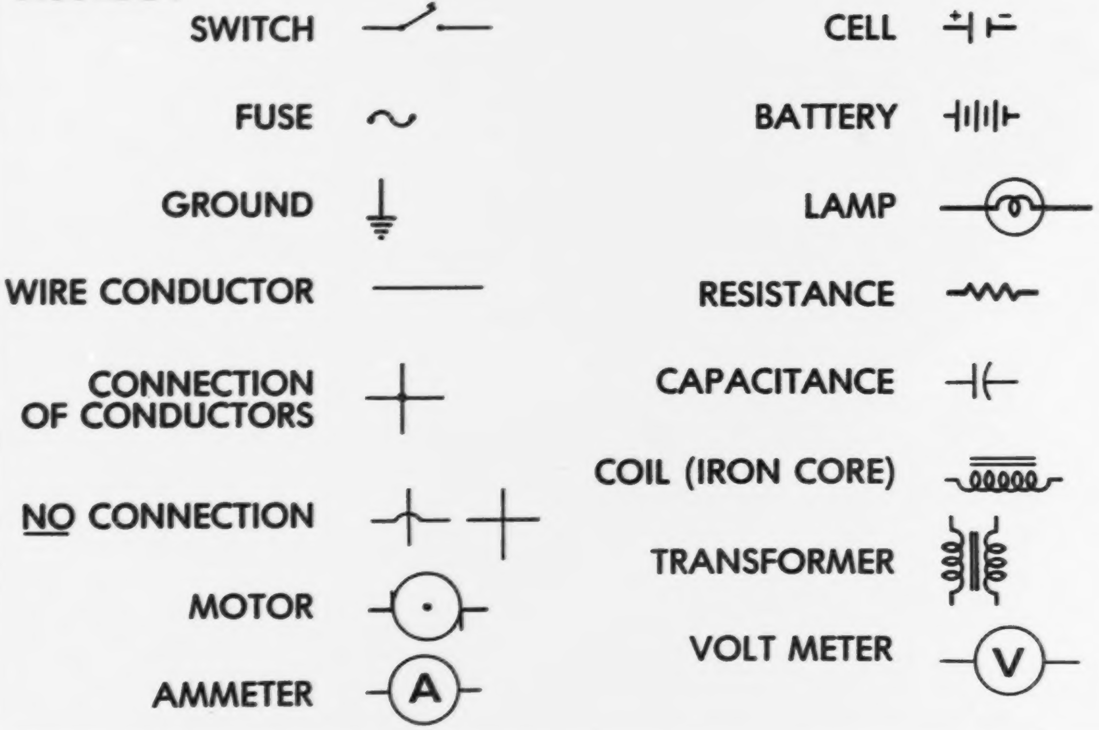
1. Read a wiring diagram.
2. Solder a wire.
3. Install a solderless terminal.
4. Splice a terminal.
5. Test a circuit.

C. Reading electrical system diagrams

(Note: Always consult vehicle specifications for wiring diagram)

1. Symbols in electrical circuits (Figure 2-1.)

FIGURE 2-1


SWITCH
FUSE
GROUND
WIRE CONDUCTOR
CONNECTION OF CONDUCTORS
NO CONNECTION
MOTOR
AMMETER
A
CELL
+
BATTERY
LAMP
RESISTANCE
CAPACITANCE
COIL (IRON CORE)
TRANSFORMER
VOLT METER
V

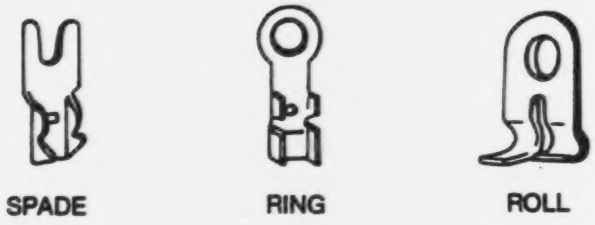
2. Routing diagrams (See HOs #1, #2, #3 & #4)

3. The fuse panel

D. Types of terminals

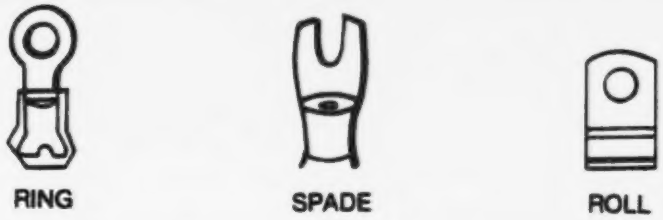
1. Solder terminals (Figure 2-2.)

FIGURE 2-2


SPADE
RING
ROLL

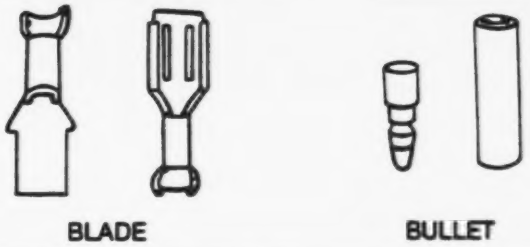
2. Solderless terminals (Figure 2-3.)

FIGURE 2-3



3. Solderless blade-and-bullet connectors (Figure 2-4.)

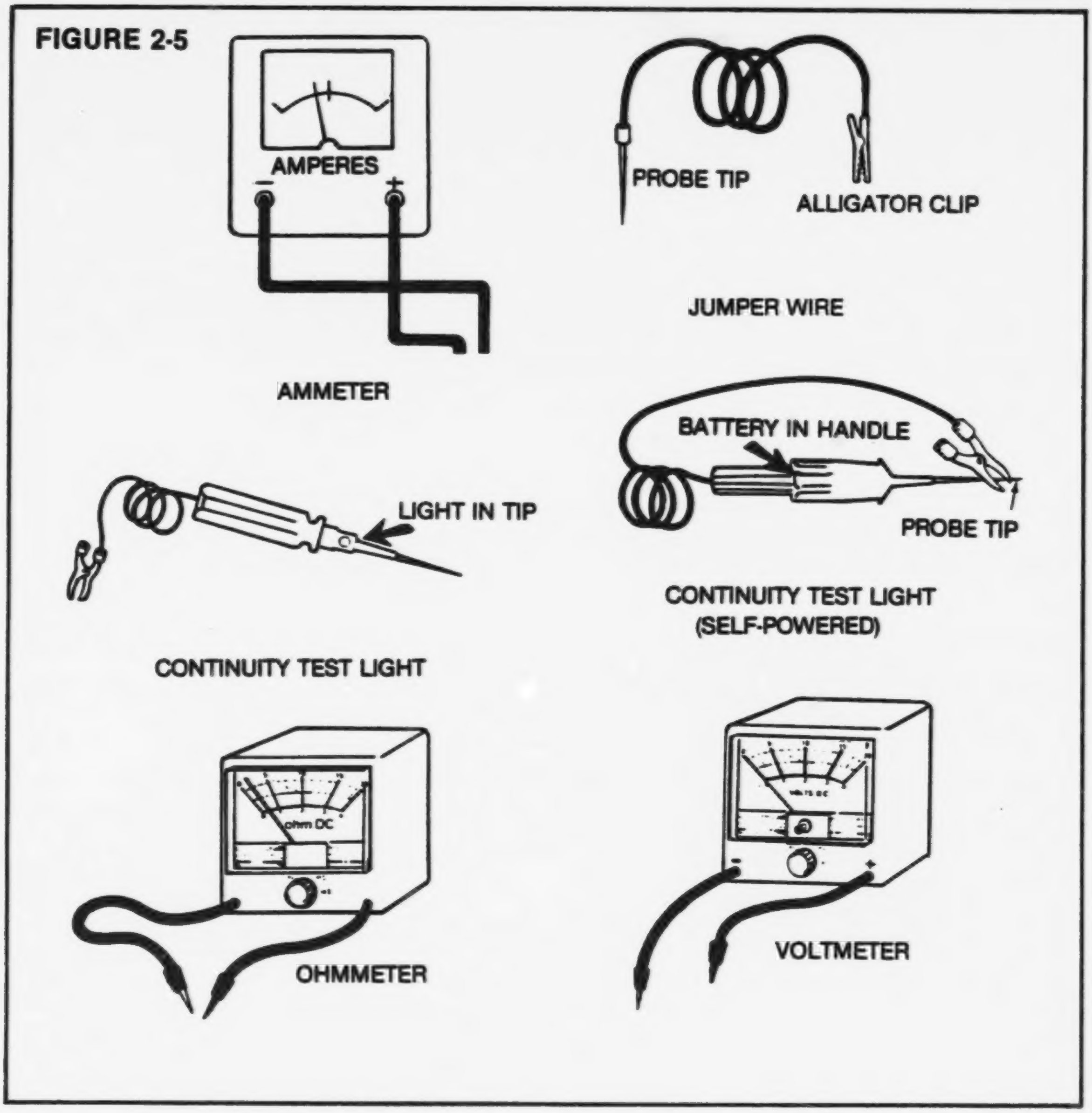
FIGURE 2-4



3. Harmonica-type connectors and harness connectors
    a. Various designs
    b. A large number of wires come together and form a many-pronged plug that plugs into a connector.

F. Troubleshooting equipment (Figure 2-5.)
    1. Induction ammeter
    2. Jumper wire
    3. Continuity test light
    4. Ohmmeter
    5. Voltmeter

FIGURE 2-5


AMPERES
−
+
AMMETER
PROBE TIP
ALLIGATOR CLIP
JUMPER WIRE
BATTERY IN HANDLE
PROBE TIP
CONTINUITY TEST LIGHT (SELF-POWERED)
LIGHT IN TIP
CONTINUITY TEST LIGHT
ohm DC
OHMMETER
VOLTMETER

G. Troubleshooting electrical systems

1. Operate circuit to check
2. Secure wiring diagram to circuit
3. Trace circuit to locate cause of problem
4. Repair
5. Retest circuit

III. Safety

A. Remove all jewelry before disconnecting battery cables or working on any electrical circuit.

B. Remove ground cable from battery before removing positive cable.

C. Disconnect battery cables before using ohmmeter.

D. Do not ground output terminal of alternator.

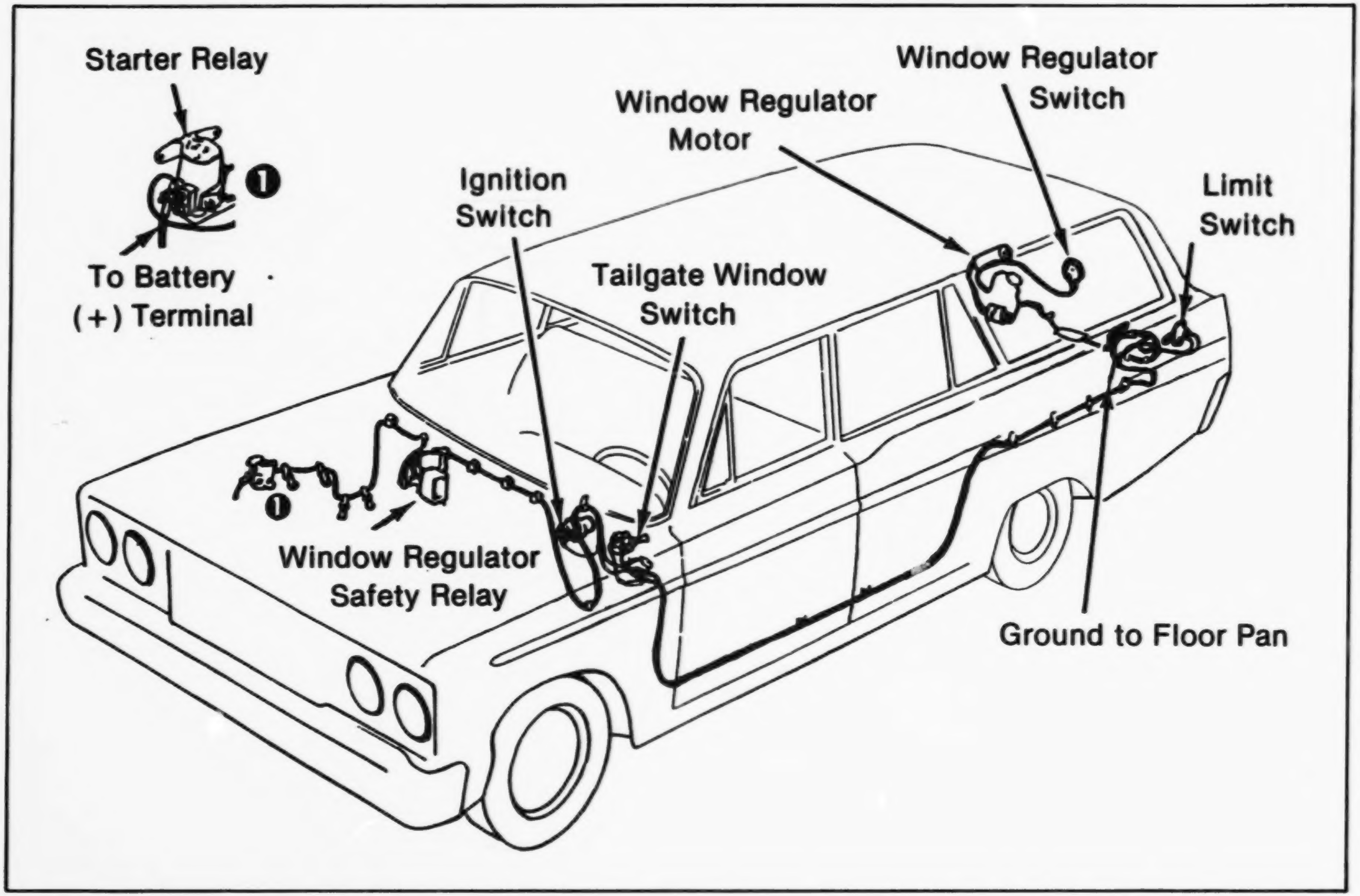
E. Never lay a conductor across the battery terminals.

F. Disconnect battery before replacing electrical components.

G. When using jumper cables, always connect ground to frame or engine.

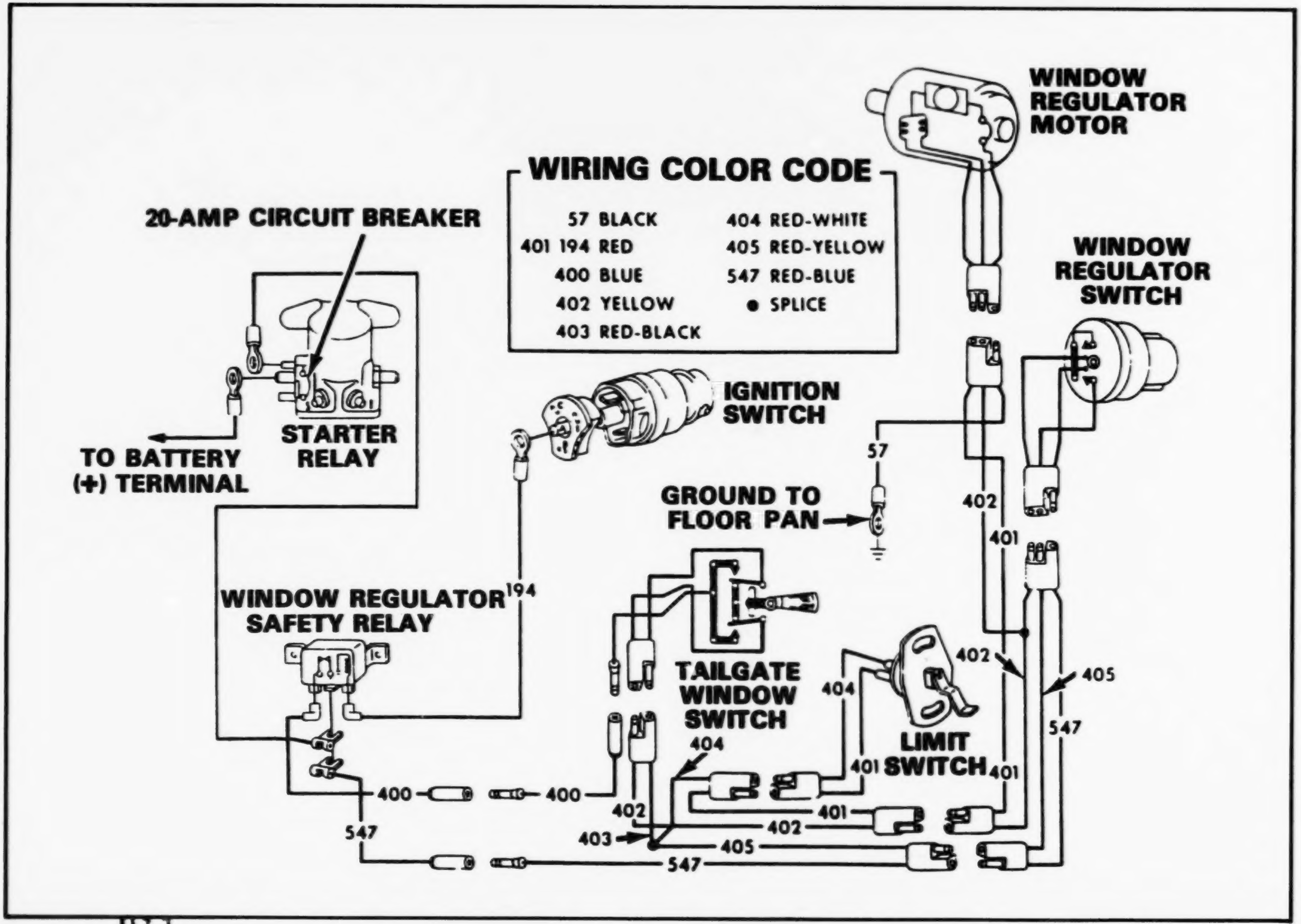
H. When using a battery charger, disconnect battery cables and connect charger to battery prior to turning on charger.

Typical Automotive Circuit

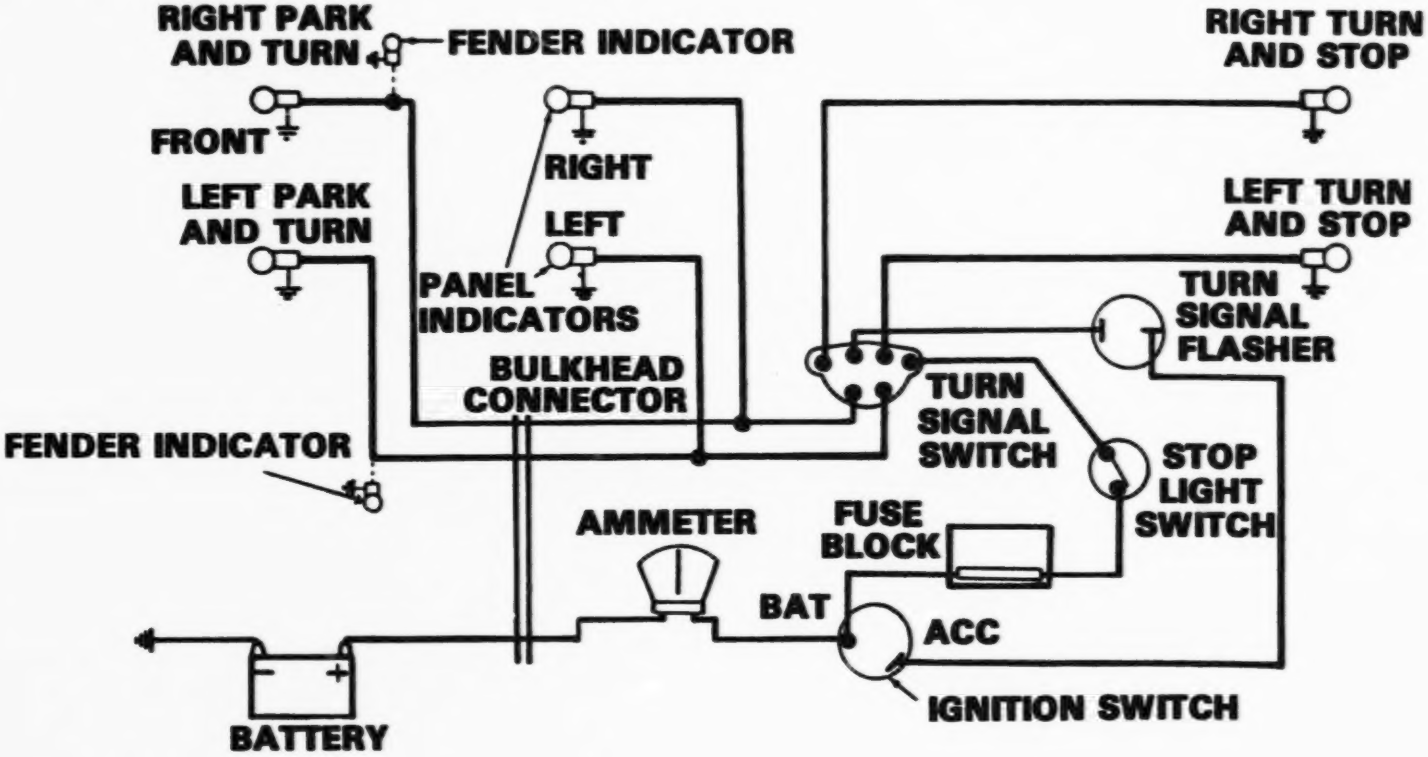

Starter Relay
❶
To Battery (+) Terminal
Window Regulator Motor
Window Regulator Switch
Ignition Switch
Limit Switch
Tailgate Window Switch
❶
Window Regulator Safety Relay
Ground to Floor Pan

HO 1

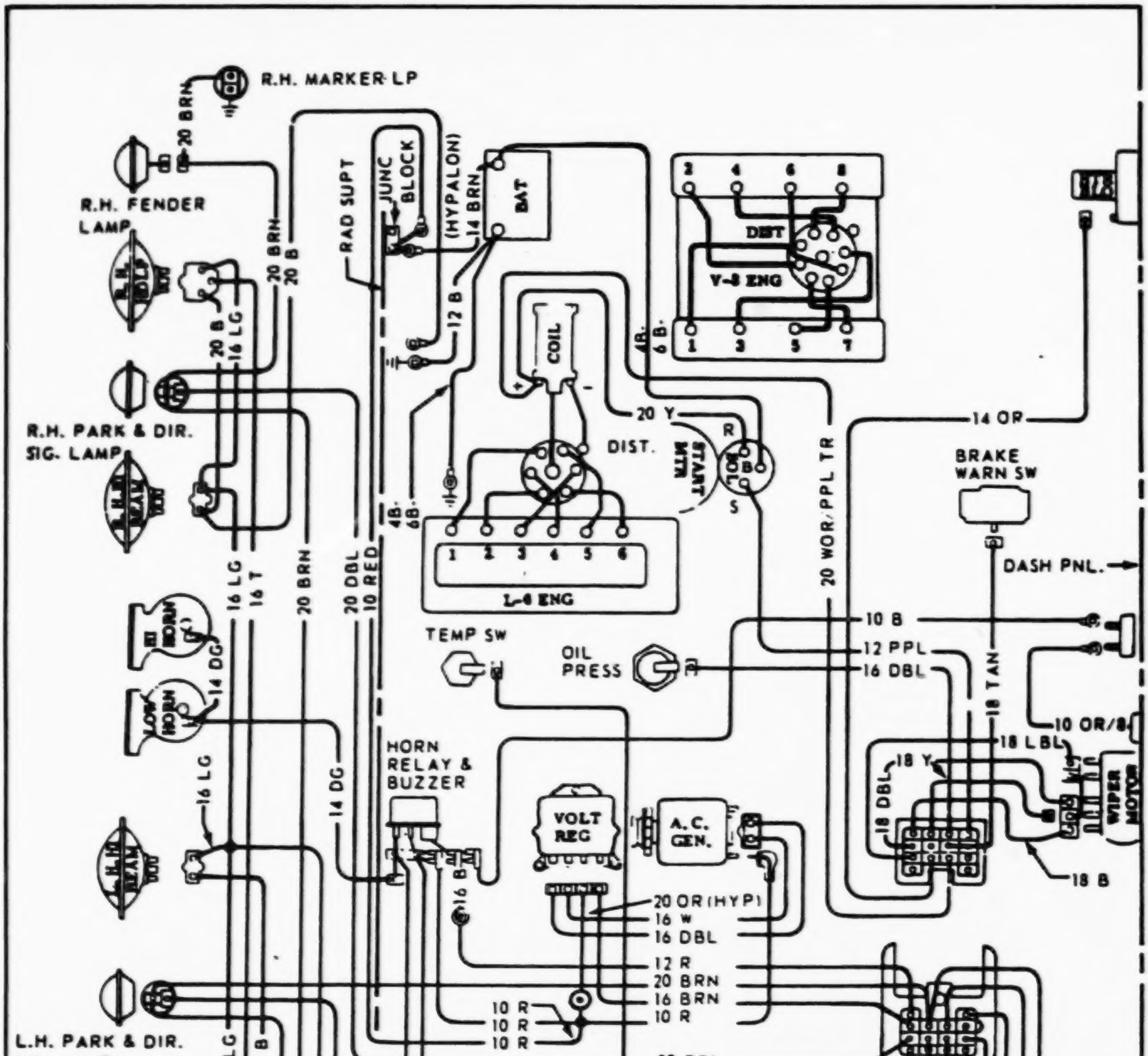
Typical Automotive Circuit (Continued)


WINDOW REGULATOR MOTOR
WIRING COLOR CODE
57 BLACK
401 194 RED
400 BLUE
402 YELLOW
403 RED-BLACK
404 RED-WHITE
405 RED-YELLOW
547 RED-BLUE
● SPLICE
20-AMP CIRCUIT BREAKER
WINDOW REGULATOR SWITCH
IGNITION SWITCH
STARTER RELAY
TO BATTERY (+) TERMINAL
57
GROUND TO FLOOR PAN
402
401
WINDOW REGULATOR SAFETY RELAY
194
TAILGATE WINDOW SWITCH
402
405
404
LIMIT SWITCH
547
404
401
401
400
400
402
401
402
403
405
547
547

Typical Signal Light Wiring Diagram


RIGHT PARK AND TURN
FENDER INDICATOR
FRONT
RIGHT
LEFT PARK AND TURN
LEFT
PANEL INDICATORS
RIGHT TURN AND STOP
LEFT TURN AND STOP
TURN SIGNAL FLASHER
BULKHEAD CONNECTOR
TURN SIGNAL SWITCH
FENDER INDICATOR
STOP LIGHT SWITCH
AMMETER
FUSE BLOCK
BAT
ACC
IGNITION SWITCH
BATTERY

Typical Engine Compartment Wiring Diagram


R.H. MARKER LP
20 BRN
R.H. FENDER LAMP
20 BRN
20 B
RAD SUPT
JUNC BLOCK
(HYPALON)
14 BRN
BAT
12 B
20 B
16 LG
R.H. PARK & DIR. SIG. LAMP
4B
6B
COIL
+
-
DIST
V-8 ENG
2
4
6
8
1
3
5
7
4B
6B
20 Y
R
START MTR
SOL
S
DIST.
1
2
3
4
5
6
L-6 ENG
14 OR
BRAKE WARN SW
DASH PNL.
16 LG
16 T
20 BRN
20 DBL
10 RED
20 WOR/PPL TR
HI HORN
14 DG
LOW HORN
TEMP SW
OIL PRESS
10 B
12 PPL
16 DBL
18 TAN
10 OR/B
18 LBL
18 Y
18 DBL
WIPER MOTOR
18 B
16 LG
14 DG
HORN RELAY & BUZZER
16 B
VOLT REG
A.C. GEN.
20 OR (HYP)
16 W
16 DBL
12 R
20 BRN
16 BRN
10 R
10 R
10 R
10 R
L.H. PARK & DIR. SIG. LAMP
16 LG
20 B
20 DBL
20 LBL
20 DG
18 LG
20 B
16 T
20 P DBL B
20 BRN
20 BRN
20 BRN
20 B
L.H. FENDER LAMP
L.H. MARKER LP

UNIT VI

JOB SHEET #1, LESSON TWO

INSTALL A SOLDERED TERMINAL

Equipment:

Soldering gun or iron
Rosin-core solder
Medium-grit sandpaper
Appropriate terminal
Electrical wire of appropriate gauge
Electrical tape
Electrician's pliers
Safety glasses

Procedure:	**Evaluation:** 3	2	1	N
(NOTE: Remove any jewelry and put on eye protection.)				
1. Strip back insulation from end of wire far enough to install terminal.	___	___	___	___
2. Clean terminal with sandpaper.	___	___	___	___
3. Place wire in terminal and bend ears of terminal around wire.	___	___	___	___
4. Solder terminal to wire. Use just enough solder to attach terminal securely.	___	___	___	___
5. Cover connection with electrical tape.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average may be used as the evaluation for competency S3 "Splice a wire.")

UNIT VI

JOB SHEET #2, LESSON TWO

INSTALL A SOLDERLESS TERMINAL

Equipment:

Appropriate terminal
Electrical wire of appropriate gauge
Electrician's pliers
Safety glasses

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
(NOTE: Remove all jewelry and put on eye protection.)				
1. Strip back insulation from end of wire far enough to install terminal.	___	___	___	___
2. Insert wire into terminal.	___	___	___	___
(NOTE: Always use a terminal that fits the wire properly.)				
3. Use electricians pliers to crimp terminal to wire using proper opening in pliers.	___	___	___	___
4. Cover connection with electrical tape.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average may be used as the evaluation for competency S3 "Splice a wire.")

UNIT VI

JOB SHEET #3, LESSON TWO

SPLICE A WIRE

Equipment:

Soldering gun or iron
Rosin-core solder
Electrical wire if needed
Electrical tape
Electrician's pliers
Safety glasses

Procedure:	**Evaluation:** 3	2	1	N
(NOTE: Remove all jewelry and put on eye protection.)				
1. Strip back insulation approximately one inch from end of wire.	__	__	__	__
2. Twist ends of wire together as snugly as possible.	__	__	__	__
3. Solder the twisted wire ends together, applying just enough solder to do the job.	__	__	__	__
4. Wrap soldered splice with electrical tape.	__	__	__	__
Average of above evaluations*	__	__	__	__

(*This average may be used as the evaluation for competency S3 "Splice a wire.")

MODULE: MECHANICAL SERVICES

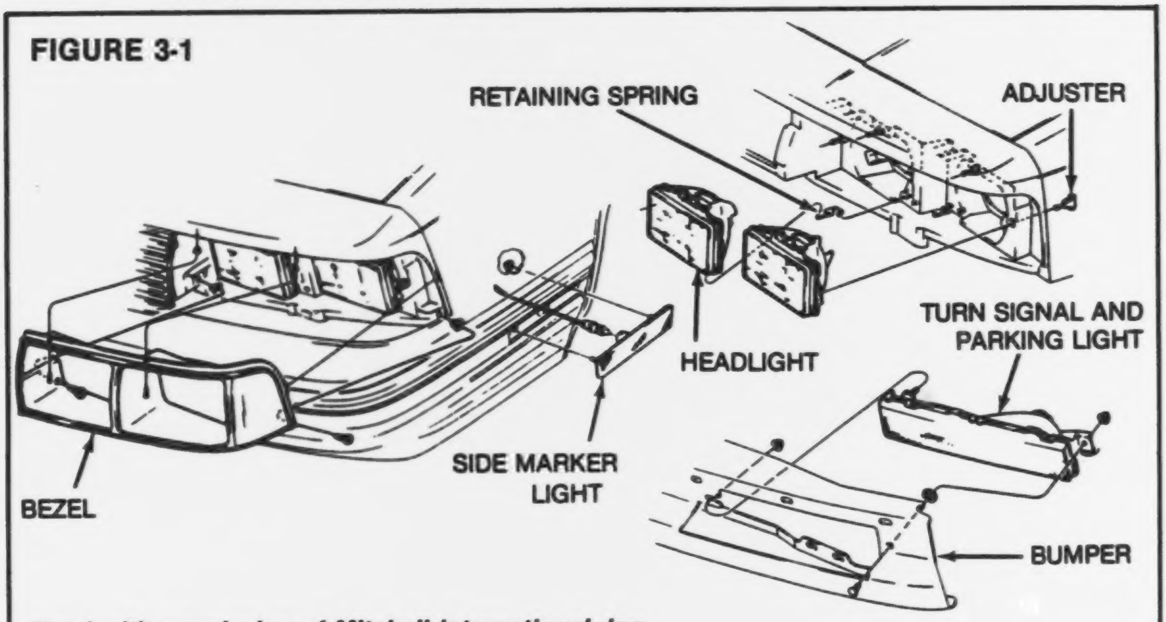
UNIT I: ELECTRICAL SYSTEMS

LESSON 3: LIGHTING SYSTEMS

I. **Headlight system components**

A. Headlight assemblies (Figure 3-1.)

FIGURE 3-1


RETAINING SPRING
ADJUSTER
TURN SIGNAL AND PARKING LIGHT
HEADLIGHT
SIDE MARKER LIGHT
BEZEL
BUMPER

Used with permission of Mitchell International, Inc.

1. Bezel
2. Headlight(s) and headlight buckets
3. Retaining spring
4. Adjuster
5. Turn signal and parking light
6. Side marker light

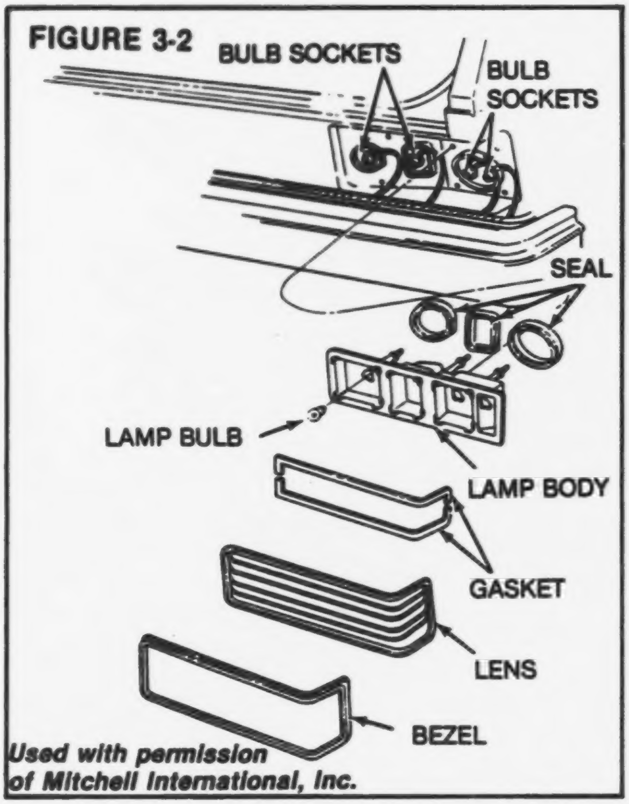
B. Headlight fasteners

1. Springs
2. Screws

II. Taillight assemblies (Figure 3-2.)

- A. Bezel
- B. Lens
- C. Gasket
- D. Lamp body
- E. Lamp
- F. Bulb sockets
- G. Seals

FIGURE 3-2


BULB SOCKETS
BULB SOCKETS
SEAL
LAMP BULB
LAMP BODY
GASKET
LENS
BEZEL

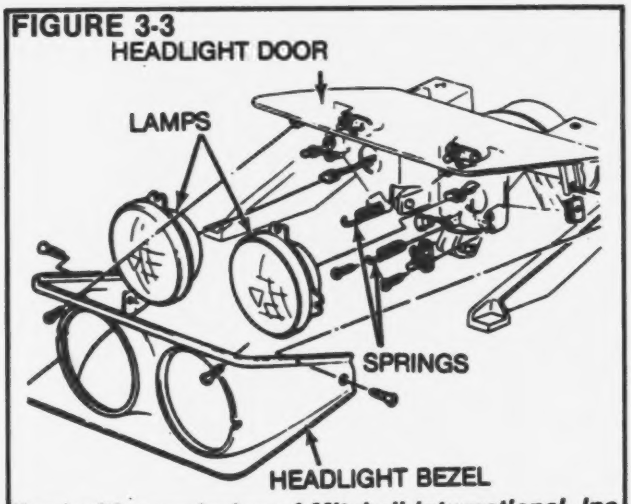
Used with permission of Mitchell International, Inc.

III. Mechanical headlights

A. Headlight door assembly (Figure 3-3.)

1. Headlight bezel
2. Springs
3. Lamps
4. Headlight door

FIGURE 3-3


HEADLIGHT DOOR
LAMPS
SPRINGS
HEADLIGHT BEZEL

Used with permission of Mitchell International, Inc.

B. Actuator assembly (Figure 3-4.)

1. Headlight door
2. Pivot bushing
3. Support
4. Actuator pivot
5. Actuator link
6. Actuator rod

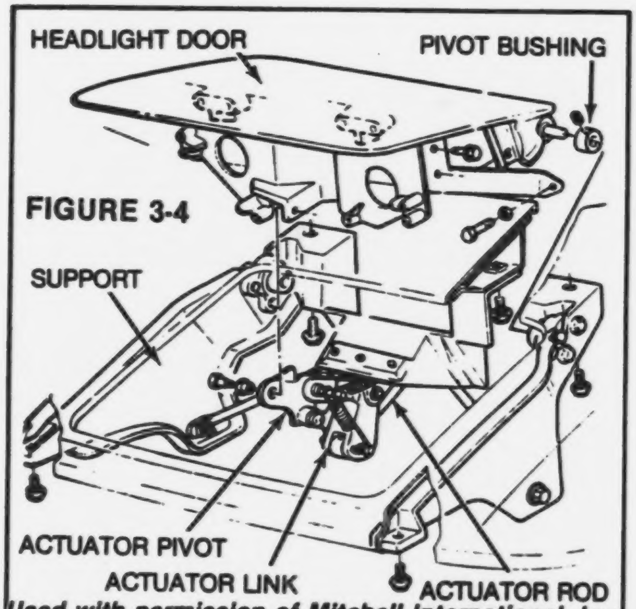


FIGURE 3-4

HEADLIGHT DOOR
PIVOT BUSHING
SUPPORT
ACTUATOR PIVOT
ACTUATOR LINK
ACTUATOR ROD

Used with permission of Mitchell International, Inc.

C. Vacuum controls (Figure 3-5.)

1. Actuator assemblies
2. Coded vacuum hoses
3. Relay valve

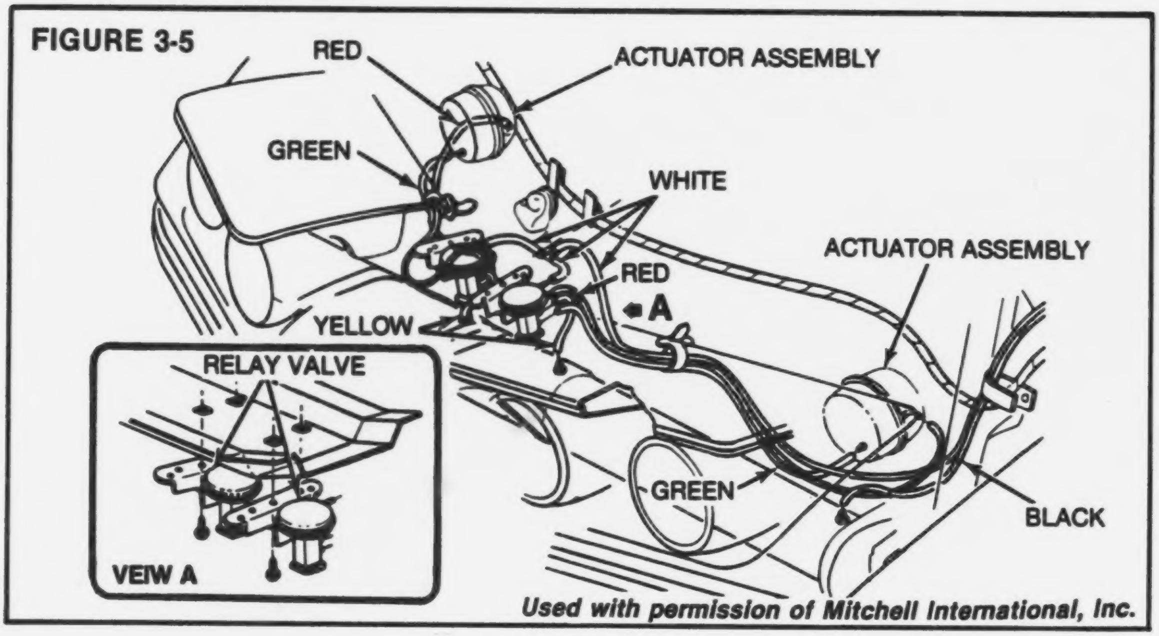


FIGURE 3-5

RED
ACTUATOR ASSEMBLY
GREEN
WHITE
ACTUATOR ASSEMBLY
RED
A
YELLOW
RELAY VALVE
GREEN
BLACK
VEIW A

Used with permission of Mitchell International, Inc.

UNIT VI

JOB SHEET #1, LESSON THREE

SERVICE HEADLIGHTS
(Remove, test and replace headlights)

Equipment:

8-inch screwdriver
General hand tools

Procedure: **Evaluation:**
3 2 1 N

1. Remove headlight bezel or trim ring. ___ ___ ___ ___

2. Unhook the springs from the bucket. ___ ___ ___ ___

3. Remove the retaining ring screws and retaining ring and remove sealed-beam assembly. ___ ___ ___ ___

   (NOTE: Do not disturb or move the adjusting screws.)

4. Disconnect the wiring assembly plug from the lamp and connect headlight to a battery. If lamp lights, test headlight switch. ___ ___ ___ ___

5. Turn on the headlight switch and test the connector with a test lamp. If test lamp does not light, test circuit. ___ ___ ___ ___

6. If lamp is defective, connect the wiring assembly plug to new lamp. ___ ___ ___ ___

   (NOTE: Automobiles with four headlights will have a "1" embossed on the inside lamps and a "2" on the outside lamps.)

7. Position the lamp so that the word "TOP" is to the right of the retaining ring tab and line up the molded lugs on the back of the lamp with the indentations in the mounting ring. ___ ___ ___ ___

8. Replace the retaining ring, then replace the springs, then replace headlight door. ___ ___ ___ ___

   (NOTE: If headlight needs adjusting, do this before replacing the headlight door.)

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for competency T2 "Service a headlight assembly.")

UNIT VI

JOB SHEET #2, LESSON THREE

AIM HEADLIGHTS

Equipment:

8-inch screwdriver
Focusing screen
Test light

Procedure:		**Evaluation:** 3	2	1	N
1.	Position screen 25 feet from car.	___	___	___	___
2.	Turn on head lamps and switch to high beam.	___	___	___	___
3.	Center screen with center of car.	___	___	___	___
4.	Cover one lamp. On cars with four lamps, cover three of the lamps.	___	___	___	___
5.	Adjust the uncovered lamp to specifications. *(NOTE: The top screw is the vertical adjustment and the side screws are the horizontal adjustment.)*	___	___	___	___
6.	Adjust each lamp to specifications.	___	___	___	___
	Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency T4: "Aim headlights using mechanical aiming equipment.")

UNIT VI

JOB SHEET # 3, LESSON 3

SERVICE TAILLIGHT ASSEMBLY

Equipment:

8-inch screwdriver
Hand tools
Manufacturer's service manual

Procedure:

		Evaluation: 3	2	1	N
1.	Open trunk lid and, if necessary, remove interior trim panels to gain access to tail lamp assembly.	___	___	___	___
2.	Remove fasteners securing tail lamp body to reinforcement panel.	___	___	___	___
3.	Remove bulb from lamp body and replace bulb.	___	___	___	___
4.	If unit does not work with new bulb, troubleshoot electrical circuit.	___	___	___	___
5.	Re-install fasteners securing tail lamp body to reinforcing panel.	___	___	___	___
6.	If necessary, replace interior trim panels.	___	___	___	___
	Average of above evaluations*	___	___	___	___

*This average is the evaluation for competency T1 "Service a taillight assembly."

UNIT VI

JOB SHEET #4, LESSON THREE

SERVICE MECHANICAL HEADLIGHTS AND COVERS

Equipment:

Hand tools, including sockets and ratchet
Screwdriver
Pliers for removing springs
Vehicle service manual

(NOTE: Mechanical headlights vary from vehicle to vehicle. Always consult vehicle service manual for exact procedure.)

Procedure:	**Evaluation:** 3	2	1	N
1. Check headlight door to see if it is damaged or binding.	___	___	___	___
2. Check vacuum hoses for damage.	___	___	___	___
3. Check actuator assembly for proper operation.	___	___	___	___
4. Check relay for proper operation.	___	___	___	___
5. Repair damage discovered.	___	___	___	___
6. Perform job sheet #1, to service headlights, making modifications as needed according to vehicle service manual.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency T3 "Service mechanical headlights and covers.")

MODULE: MECHANICAL SERVICES

UNIT I: ELECTRICAL SYSTEMS

UNIT I TEST

I. Match the terms in the left column with the most closely associated terms in the right column

_____1. Uses electrical symbols

_____2. Produces current

_____3. Designed to break circuit

_____4. Insulator failure ·

_____5. Stores current

_____6. Steady flow in same direction

_____7. Lead post

_____8. Strength of current

_____9. Amount of pressure

_____10. Absorbs current flow

_____11. Path from positive to negative

_____12. Allows current flow

A. Amperage

B. Battery

C. Circuit

D. Ground

E. Terminal

AB. Voltage

AC. Alternator

AD. Condenser

AE. Conductor

BC. Fuse

BD. Short circuit

BE. Wiring diagram

CD. Direct current

II. Match the electrical symbols in the diagram below with the term the symbol represents.

_____13. Switch

_____14. Cell

_____15. Wire conductor

_____16. Resistance

_____17. Fuse

_____18. Battery

_____19. Connection

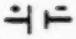
_____20. Capacitance

_____21. Ground

_____22. Lamp

_____23. No connection

_____24. Motor

A.


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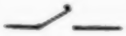

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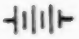

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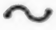
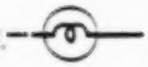
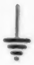
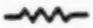


E.


AB.


AC.


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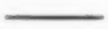
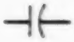
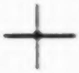
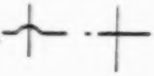
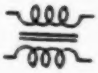
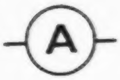


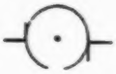
AE.


BC.


BD.


BE.


CD.


CE.


III. Match the correct letter(s) from the diagram with the name of the component.

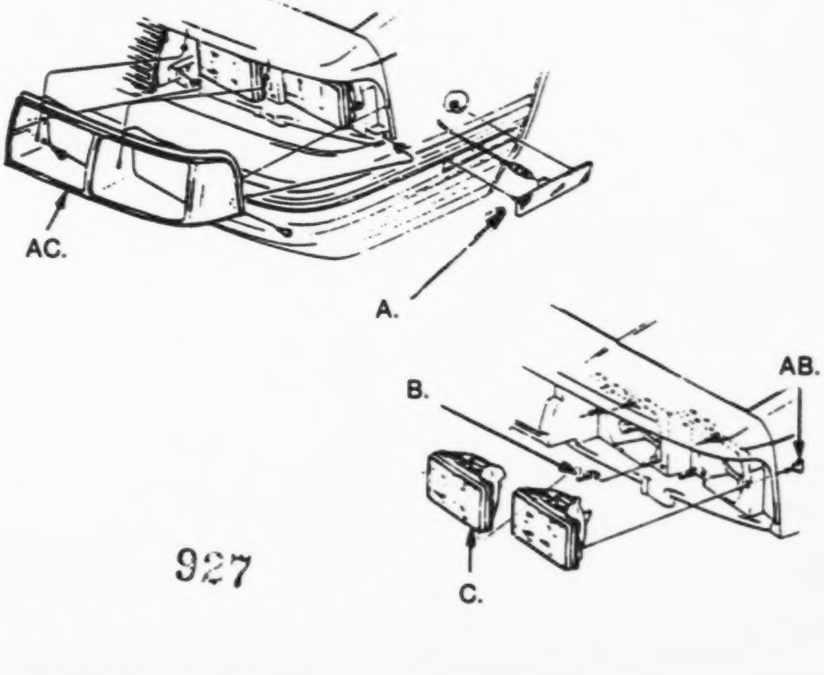
_____25. Bezel

_____26. Side marker light

_____27. Retaining spring

_____28. Adjuster

_____29. Headlight



IV. Match the correct letter(s) from the diagram with the name of the component.

_____30. Bulb socket

_____31. Gasket

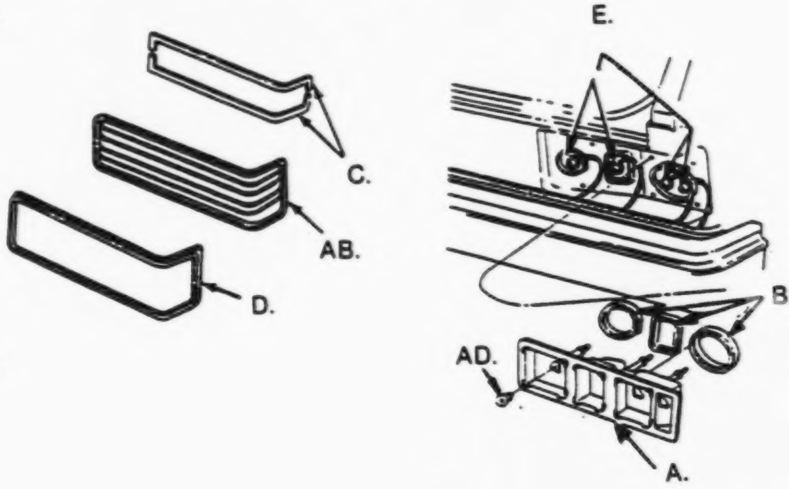
_____32. Lens

_____33. Bezel

_____34. Seal

_____35. Bulb

_____36. Lamp body



V. Match the correct letter(s) from the diagram with the name of the component.

_____37. Headlight door

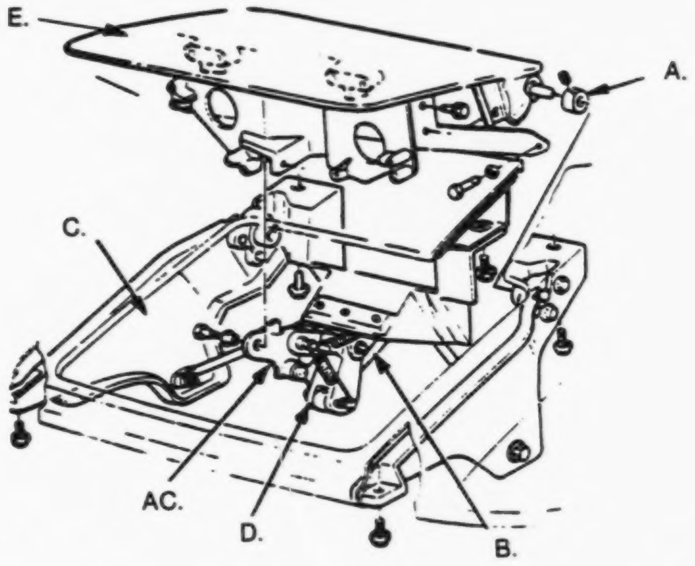
_____38. Pivot bushing

_____39. Support

_____40. Actuator pivot

_____41. Actuator link

_____42. Actuator rod



VI. Select the best answer from the choices listed.

_____43. The procedure of using a hydrometer to check the condition of a battery is called the: (a) load test, (b) three-minute charge test, (c) specific gravity test, (d) cadmium test, (e) battery-rating test.

_____44. A fully charged battery has a specific gravity of: (a) 1.120, (b) 1.280, (c) 1.520, (d) 1.860, (e) 2.050.

_____45. Slow-charging a battery is a procedure that should take: (a) three minutes, (b) one to two hours, (c) four to six hours,, (d) 14 to 16 hours, (e) 24 hours.

_____46. Fast-charging a battery is a procedure that should take: (a) 15 seconds, (b) one to two hours, (c) four to six hours,, (d) 14 to 16 hours, (e) 24 hours.

_____47. When using jumper cables, always connect the ground cable to the: (a) frame or engine, (b) positive terminal, (c) distributor, (d) battery post, (e) any rubberized material.

_____48. When disconnecting battery cables, you should: (a) remove the ground cable first, (b) remove the positive cable first, (c) shut off all electrical components, (d) open the cells, (e) ground the battery first.

_____49. On a wiring diagram: (a) lines represent wires, (b) the color codes for wires are given, (c) symbols indicate components, (d) a complete circuit is shown, (e) all of the above.

(NOTE: Completion of this unit test with a minimum score of _____ is necessary for the student to receive an evaluation for competencies S2-S3 and T1-T4. It is also the evaluation for Competency S1 "Identify electrical system components." Of the 49 questions, a score of ____ correct = 3, ____ correct = 2, ____ correct = 1, and ____ correct or below = student should retake this portion of the test.)

ANSWERS TO UNIT I TEST

1. BE
2. B
3. BC
4. BD
5. AD
6. CD
7. E
8. A
9. AB
10. D
11. C
12. AE

13. B
14. A
15. AD
16. AC
17. D
18. C
19. BC
20. AE
21. AB
22. E
23. BD
24. CE

25. AC
26. A
27. B
28. AB
29. C

30. E
31. C
32. AB
33. D
34. AC
35. AD
36. A

37. E
38. A
39. C
40. AC
41. D
42. B

43. C
44. B
45. D
46. A
47. A
48. A
49. E

MODULE: MECHANICAL SERVICES

UNIT II: ENGINE COOLING SYSTEMS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify engine cooling systems and repair and replace cooling system components. Mastery will be evidenced through demonstration and by scoring ____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Match terms with their definitions or illustrations (Competency U1-U5, Unit II test)

II. Identify the purposes of cooling system components (Competency U1-U5, Unit II test)

III. Identify liquid- and air-cooled system components (Competency U1-U5, Unit II test)

IV. Identify hoses, clamps and drive belts (Competency U2, U5, Unit II test)

V. Identify temperature gauges (No Competency)

VI. Identify heater system (No Competency)

VII. Demonstrate the ability to:

   a. Inspect and service radiator and heater hoses (Competency U5, JS#1)

   b. Remove, inspect and replace V-belts (Competency U2, JS#2)

Lesson 2:

I. Identify operation of radiator (Competency U1, Unit II test)

II. Identify operation of thermostat (No Competency)

III. Demonstrate the ability to:

   a. Remove and replace a radiator (Competency U1, JS#1)

Lesson 3:

I. Identify types of fans (Competency U4, Unit II test)

II. Identify principles of thermo-clutch fan (Competency U4, Unit II test)

III. Identify principles of electric fan (Competency U4, Unit II test)

IV. Identify anti-freeze properties (Competency U3, Unit II test)

V. Demonstrate the ability to:

  a. Service fan blades and clutches (Competency U4, JS#1)

  b. Inspect and service electrical fan motors (Competency U4, JS#2)

  c. Test antifreeze solutions (Competency U3, JS#3)

MODULE: MECHANICAL SERVICES

UNIT II: ENGINE COOLING SYSTEMS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Notes to the instructor

C. References

D. Lesson plans

1. Lesson 1: Engine Cooling Systems

   a. Information outline

   b. Handouts

   HO#1: Cooling system components (liquid-cooled)
   HO#2: Cooling system components (air-cooled)
   HO#3: Hoses and clamps
   HO#4: Fan belt adjustment
   HO#5: Temperature gauges
   HO#6: Heater operation

   c. Job sheets

   JS#1: Inspect and service radiator and heater hoses
   JS#2: Inspect and service belts

2. Lesson 2: Radiator, Thermostat, Water Pump

   a. Information outline

   b. Handouts

   HO#1: Typical downflow radiator
   HO#2: Typical radiator core construction
   HO#3: Coolant recovery system
   HO#4: Pellet-type thermostat
   HO#5: Typical bellows thermostat

   c. Job sheets

   JS#1: Remove and replace radiator

3. Lesson 3: Fans

   a. Information outline

   b. Handouts

   HO#1: Types of cooling fans
   HO#2: Fan clutch operation

c. Job sheets

JS#1: Service fan blades and clutches
JS#2: Inspect and service electrical fan motors
JS#3: Test antifreeze solution

E. Unit test

F. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Due to this unit receiving a low priority, the information presented is not as thorough as in the bulk of the material in this curriculum. For that reason, supplemental material will have to be used for students to gain a better understanding. The units in this module are not as suitable as material in the other modules for independent study by the student.

REFERENCES USED IN WRITING THIS UNIT

1. Crouse, William H. *Automotive Mechanics.* Eighth edition. McGraw-Hill. St. Louis, MO. 1980.

2. Gaines, Jim, and Downing, Ronald. *Auto Mechanics. Automotive Cooling and Lubrication Systems and Service Procedures.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1981.

3. Stockel, Martin W. *Auto Mechanics Fundamentals.* Fourth edition. Goodheart-Willcox. South Holland, IL. 1978.

4. Stockel, Martin W. *Auto Service and Repair.* Third edition. South Holland, IL. Goodheart-Willcox. 1978.

5. Toboldt, William K., and Johnson, Larry. *Automotive Encyclopedia.* Sixth edition. Goodheart-Willcox. South Holland, IL. 1979.

MODULE: MECHANICAL SERVICES

UNIT II: ENGINE COOLING SYSTEMS

LESSON 1: PRINCIPLES OF COOLING SYSTEMS

I. **Terms and definitions**

A. Coolant -- Any liquid that circulates through a cooling system to transfer engine heat.

B. Coolant recovery system -- A plastic tank usually mounted on inner fender which accepts coolant from the cooling system as it expands due to heat, and then returns it to the radiator as it cools.

C. Fan -- Bladed device generally mounted on the water pump hub assembly to pull air through the radiator core.

(NOTE: On most front-wheel-drive vehicles, the fan is powered by an electric motor. The fan motor is turned on and off as required by a heat-sensor switch, usually mounted on the radiator tank.)

D. Pressure cap -- A cap on top of the radiator which closes the cooling system, allowing pressure to increase within the cooling system several pounds per square inch (psi), thus allowing coolant to circulate at higher temperatures without evaporating.

(NOTE: The temperature required to boil water increases as pressure in the cooling system increases. One additional pound of pressure per square inch raises the boiling point of water approximately 3° Fahrenheit.)

E. Radiator -- The device within the cooling system which transfers heat from the cooling system to the surrounding air.

F. Radiator core -- That part of radiator which allows air to pass over the contained coolant to provide cooling.

G. Shroud -- Structure attached to the radiator and extending around the fan; used to make the fan more effective in pulling air through the radiator core.

H. Thermostat -- A valve regulated by heat which is used in a cooling system to regulate the flow of coolant (or air, in the case of air-cooled engines) thereby controlling the operating temperature of the engine.

I. Vacuum brazing -- Brazing aluminum without the use of flux. Flux contains salt, which causes corrosion and can damage aluminum materials.

J. Water jackets -- Passages through the block and cylinder head(s) that allow coolant to circulate through the engine.

K. Water pump -- A pump mounted at front of engine and driven by the engine, which circulates coolant through the cooling system.

II. Cooling systems

- A. Purposes of the cooling system
    - 1. Removes excess heat
    - 2. Maintains efficient operating temperature
    - 3. Brings engine to operating temperature quickly
- B. Types of cooling systems: Liquid-cooled, Air-cooled
- C. Disadvantages of running "too cool"
    - 1. Poorer engine performance
    - 2. Poorer fuel economy
    - 3. Greater engine wear
    - 4. Higher exhaust emission
- D. Cooling system requirements
    - 1. One-third of combustion heat energy must be removed by cooling system
    - 2. One-third of combustion heat leaves through exhaust system
    - 3. One-third of combustion heat energy is used to drive vehicle

III. Principles of operation

- A. Liquid-cooled (See HO#1)
    - 1. Coolant absorbs heat from engine
    - 2. Water pump circulates coolant
    - 3. Radiator dissipates coolant heat
    - 4. Thermostat controls engine temperature
    - 5. Direction of coolant flow--with thermostat closed
        - a. water pump
        - b. block
        - c. head
        - d. water by-pass

6. Direction of coolant flow--with thermostat open
    a. pump
    b. block
    c. head
    d. thermostat
    e. upper radiator hose
    f. radiator
    g. lower radiator hose

B. Principles of operation, air-cooled (See HO #2.)
    1. Cooling fins -- Transfer and dissipate engine heat
    2. Blower -- Circulates air over engine
    3. Engine shrouds -- Control air direction
    4. Thermostat -- Regulates amount of air circulated
    5. Comparison to liquid-cooled engine
        a. Higher operating temperatures
        b. Noisier operations -- no water jackets to deaden sound
        c. Never "lug" engine -- causes overheating

IV. **Hoses, clamps and drive belts**

A. Types of hoses (See HO #3.)
    1. Common hose -- used when no bends are required.
    2. Molded or shaped hose -- designed for specific locations. All new car radiator hoses are molded.
    3. Accordion-type hose -- universal; one hose fits many needs; bends sharply.

B. Hose Construction
    1. Rubber and fabric
    2. Steel-wire coil in some types

C. Signs of hose deterioration
    1. Cracking
    2. Hardening

   3. Ballooning

D. Types of hose clamps (See HO #3.)

   1. Screw-type

   2. Snap-type

E. Drive Belts

   1. Effects of belt tension too tight

      a. Premature wear of accessory bearings

      b. Premature belt wear

   2. Effects of belt tension too loose

      a. Noisy belt

      b. Premature belt wear

      c. Inoperative accessories

F. Checking belt tension

   1. Tension gauge method

   2. Hand method (See HO #4.)

      a. Apply firm pressure at longest interval between pulleys

      b. Belt should deflect about 1/2-inch

G. Belt Inspection

   1. Cracking

   2. Splitting

   3. Fraying

   4. Oil-soaked

   5. Hard glazing

V. **Temperature gauges**

A. Temperature indicator devices

   1. Electrical

      a. Gauge-type

      b. Indicator light type

        c. Sending unit -- indicator light and gauge-type sending units are not interchangeable

        d. Instrument constant voltage regulator -- used with bimetal gauge-type indicators

    2. Gas-filled or mechanical type

        a. Sensing bulb

        b. Capillary tube

        c. Bourdon tube

B. Operation of electrical gauge (See HO #5.)

    1. Engine cold

        a. Sending unit resistance high

        b. Current flow through gauge is less

    2. Engine hot

        a. Sending unit resistance is low

        b. Current flow through gauge is high

C. Operation of indicator light

    1. Turn-on temperature -- about 250° F.

    2. Engine cold

        a. Sending unit has open circuit

        b. No current flow through light bulb

        c. Light is out

    3. Engine hot

        a. Sending unit becomes grounded

        b. Current flows through bulb

        c. Indicator light glows

D. Operation of gas-filled (See HO #5.)

    1. Engine cold

        a. Bulb liquid contracts

        b. Pressure in capillary tube is low

        c. Bourdon tube contracts to cold position

    2. Engine hot

        a. Bulb liquid becomes heated and evaporates

        b. Pressure in capillary tube increases

        c. Bourdon expands to hot position

E. Indicator light prove-out circuit

    1. Purpose -- to verify operation of the indicator light bulb

    2. Operation -- indicator light automatically glows when ignition key is turned to START position

VI. **Heater**

A. Heater core construction

    1. Cellular core

    2. Inlet & outlet tubes

B. Principles of Operation of (See HO #5.)

C. Heater hoses

    1. Inlet

        a. Connects to head, block, or intake manifold

        b. Usually the smaller size of the two

    2. Outlet

        a. Connects to water pump

        b. Usually the larger of the two

D. Water Valve

    1. Allows hot water to enter heater core for heating

    2. Shuts off hot water for air conditioning

    3. Valve is normally open -- closes when vacuum is applied

E. Heater core -- transfers engine coolant heat to the air

F. Heater housing

    1. Houses heater components

   2. Controls the temperature, amount and discharge of air

G. Blower motor -- pushes air through heater housing

H. Blower motor resistor

   1. Controls blower motor speeds

   2. Located in incoming air stream of heater housing to prevent its overheating

   3. Regulates amount of current reaching blower motor

I. Vacuum motors -- open-and-close deflector doors in heater housing

J. Control head

   1. Cable controls temperature blend door

   2. Vacuum switch applies vacuum to vacuum motors

   3. Fan switch controls blower motor

K. How air temperature is controlled

   1. Cable operates temperature blend door

   2. For HOT air - air is directed THROUGH heater core

   3. For COOL air - air deflected AROUND heater core

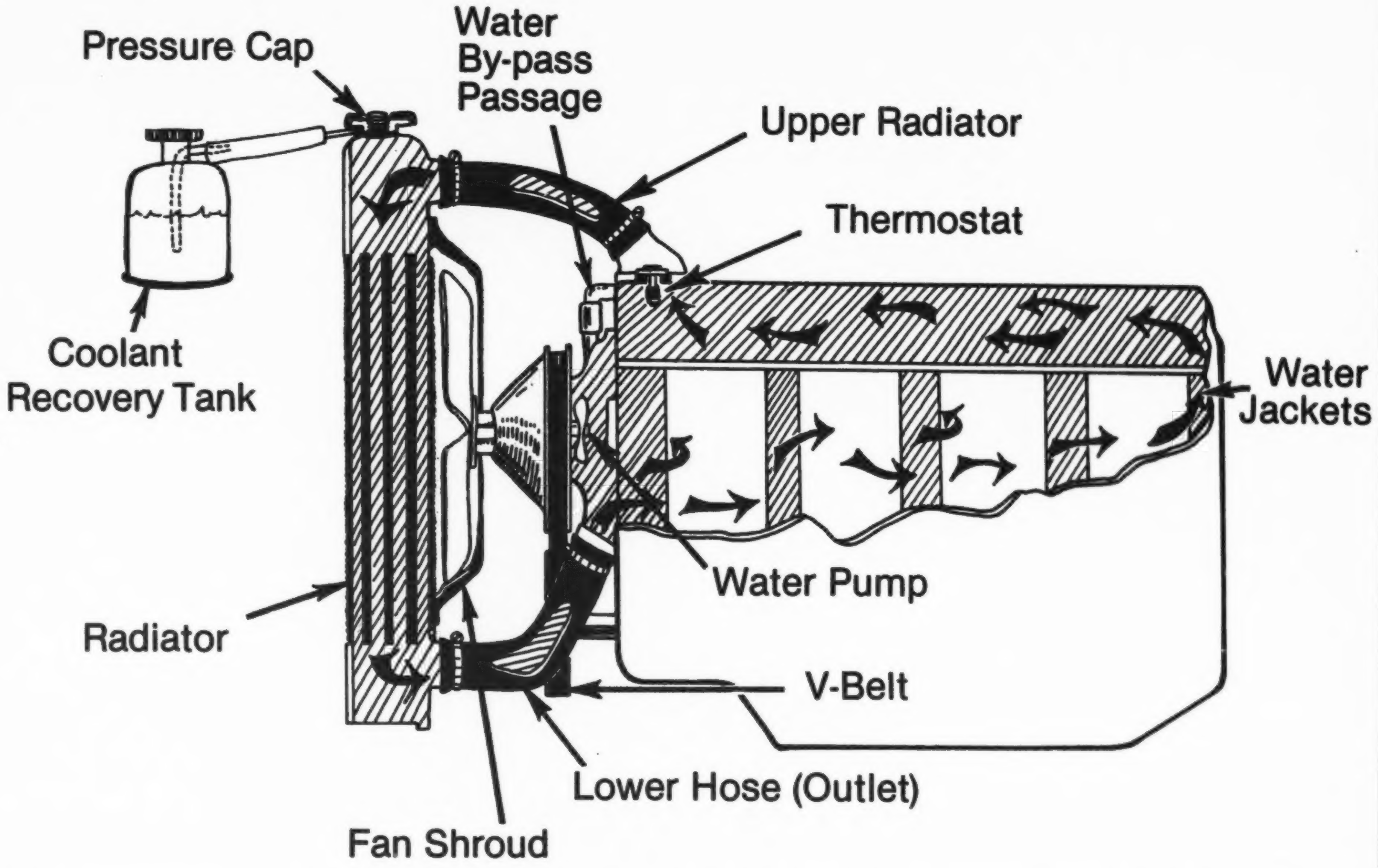
L. Signs of heater core leakage

   1. Smell of antifreeze

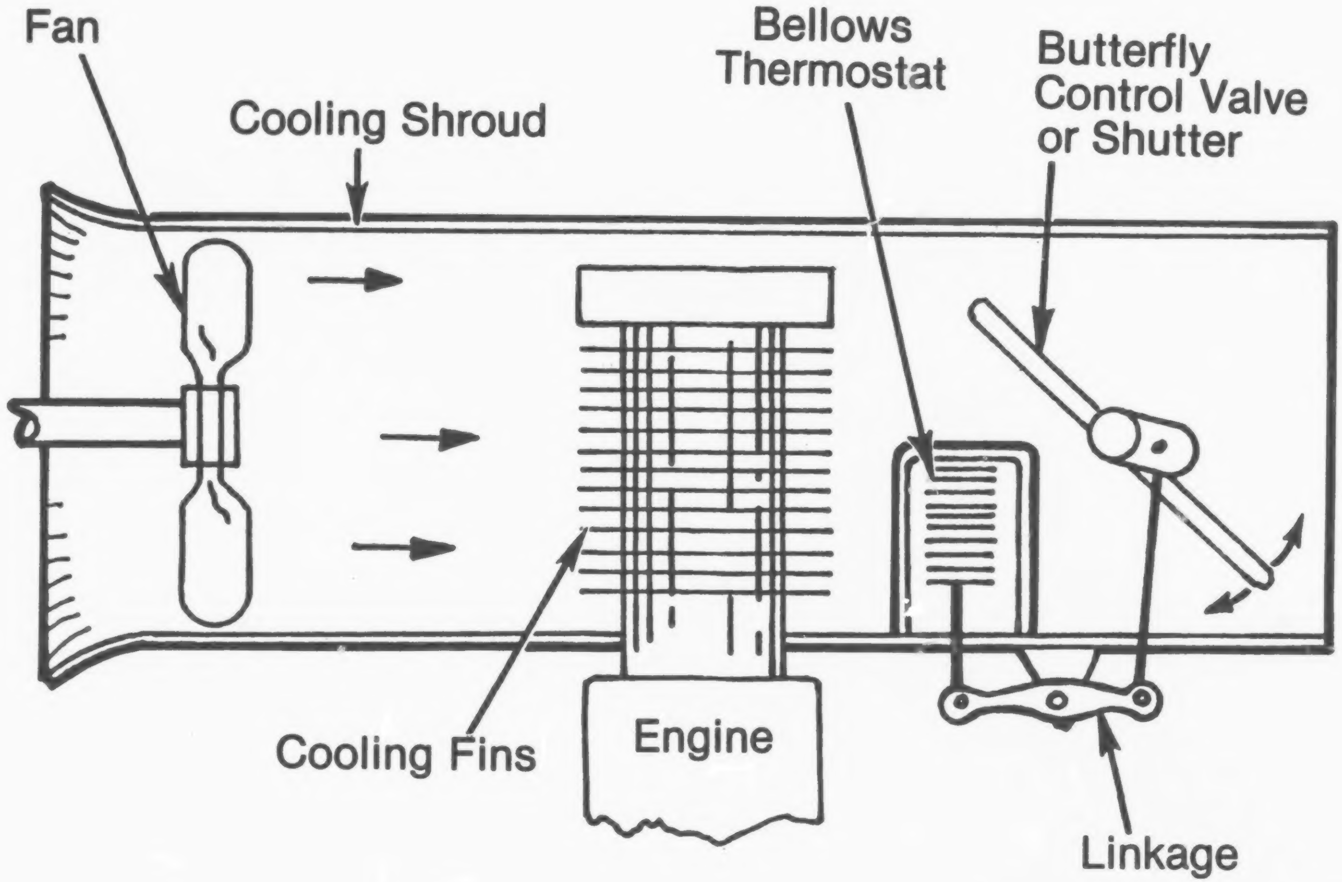
   2. Fogging on inside of windows

   3. Coolant leakage under dash

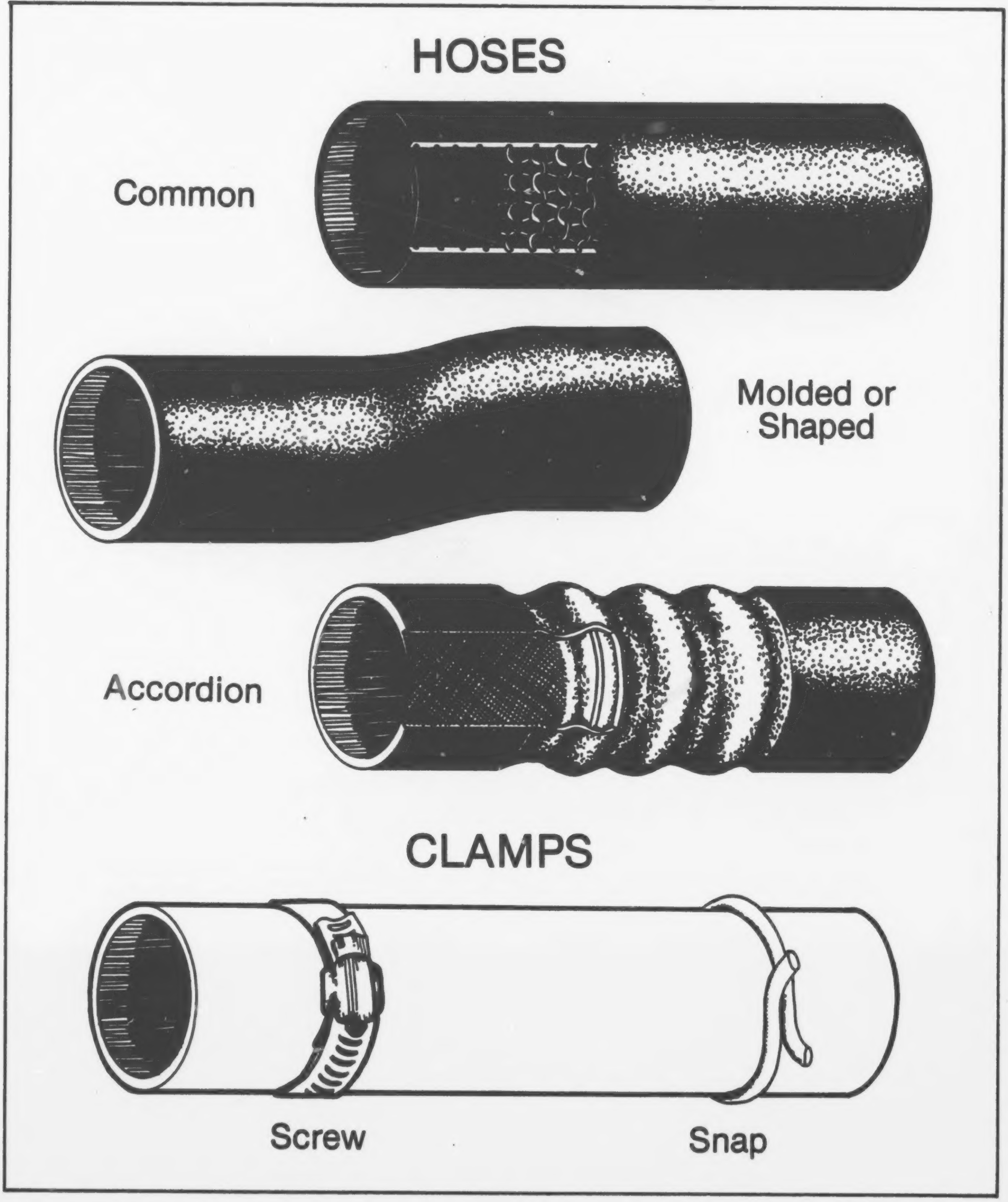
Cooling System Components (Liquid Cooled)


Pressure Cap
Water By-pass Passage
Upper Radiator
Thermostat
Coolant Recovery Tank
Water Jackets
Water Pump
Radiator
V-Belt
Lower Hose (Outlet)
Fan Shroud

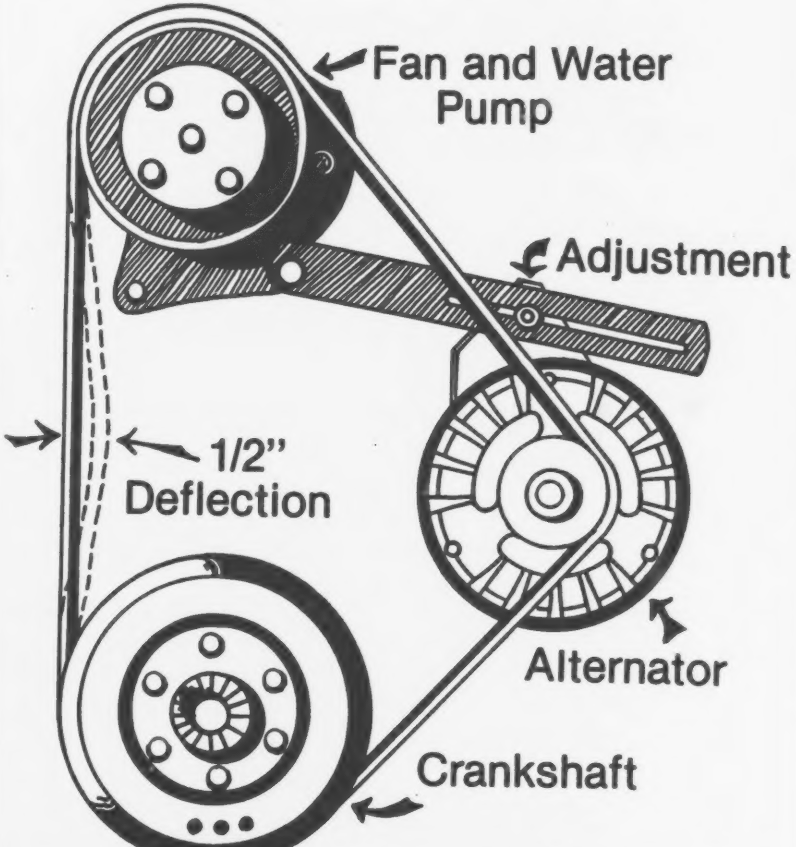
Cooling System Components (Air Cooled)


Fan
Cooling Shroud
Bellows Thermostat
Butterfly Control Valve or Shutter
Cooling Fins
Engine
Linkage

Hoses And Clamps

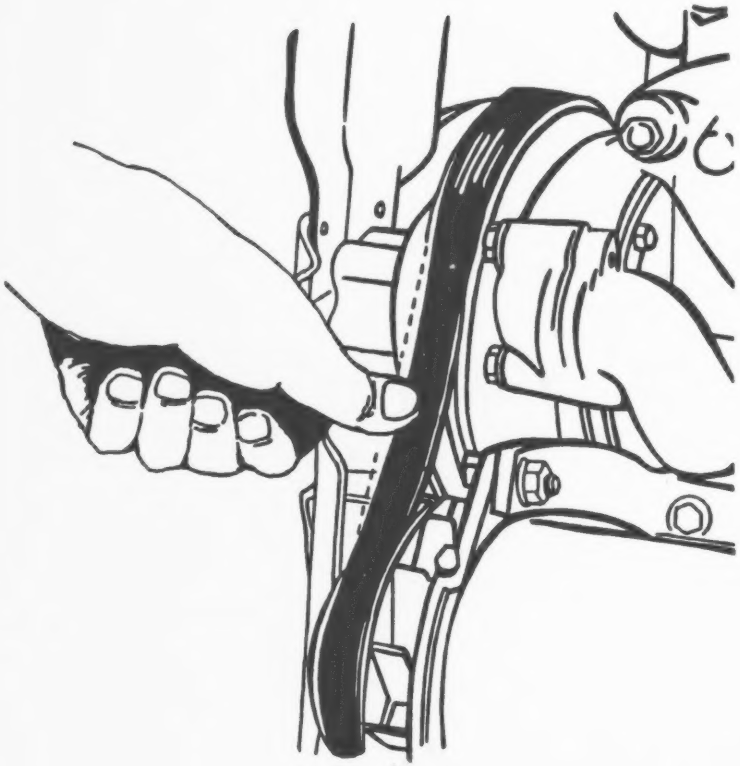

HOSES
Common
Molded or Shaped
Accordion
CLAMPS
Screw
Snap

Fan Belt Adjustment


Fan and Water Pump
Adjustment
1/2" Deflection
Alternator
Crankshaft

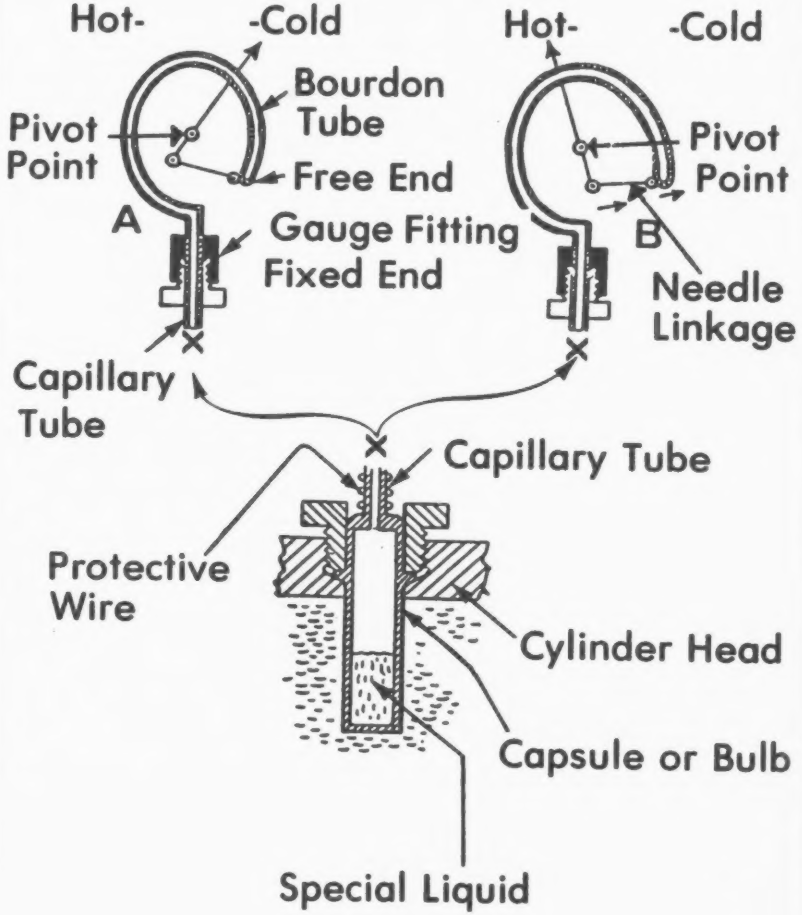
Belt Adjustment

Testing Belt Adjustment

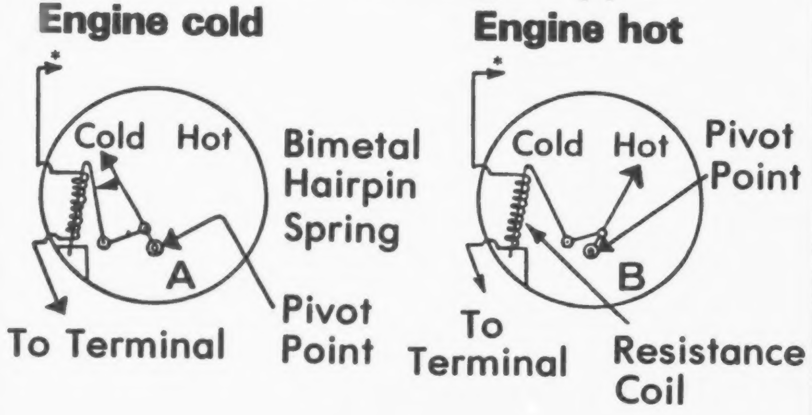


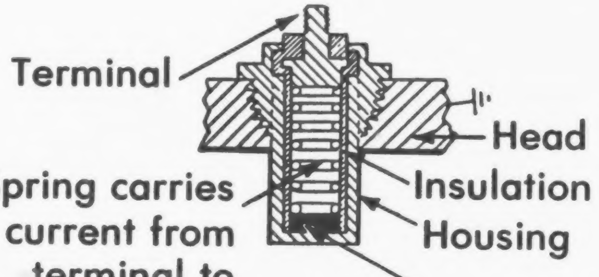
Temperature Gauges

Bourdon Tube


Hot-
-Cold
Bourdon Tube
Pivot Point
Free End
A
Gauge Fitting
Fixed End
Capillary Tube
Hot-
-Cold
Pivot Point
B
Needle Linkage
Capillary Tube
Protective Wire
Cylinder Head
Capsule or Bulb
Special Liquid

Constant Voltage Type


Engine cold
*
Cold
Hot
A
Bimetal Hairpin Spring
To Terminal
Pivot Point
Engine hot
*
Cold
Hot
Pivot Point
B
To Terminal
Resistance Coil

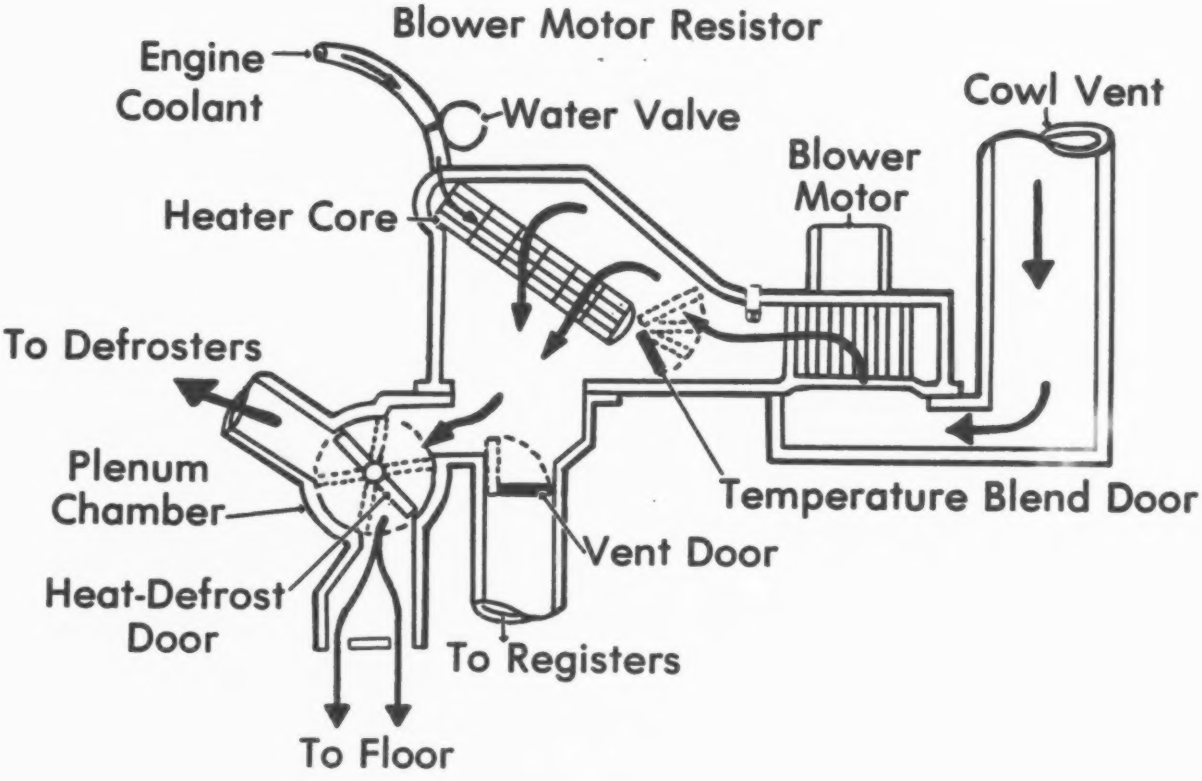

Terminal
Head
Insulation
Housing

Spring carries current from terminal to temperature sensitive disc.

Temperature Sensitive Material. This disc will conduct electricity through itself to ground. The hotter it gets the more it will conduct.

* To Constant Voltage Source

Heater Operation


Blower Motor Resistor
Engine Coolant
Water Valve
Cowl Vent
Blower Motor
Heater Core
To Defrosters
Plenum Chamber
Temperature Blend Door
Vent Door
Heat-Defrost Door
To Registers
To Floor

1. Outside air enters cowl vent.
2. Blower motor pushes air through heater core.
3. Water valve provides hot engine coolant to warm heater core.
4. Heater core transfers engine coolant heat to air.
5. Plenum chamber directs heated air to floor and/or heater ducts.
6. Blower motor resistor varies blower speed.

UNIT II

JOB SHEET #1, LESSON ONE

INSPECT AND SERVICE RADIATOR AND HEATER HOSES

Equipment

Screwdriver
Appropriate hoses

Procedure:

		Evaluation: 3	2	1	N
1.	Check hoses for cracking, hardening ballooning or leaking.	___	___	___	___
2.	Check clamps for excessive corrosion.	___	___	___	___
3.	If lower radiator hose must be replaced, drain cooling system.	___	___	___	___
4.	Remove clamps on hoses to be replaced.	___	___	___	___
5.	Replace with exact new hose.	___	___	___	___
6.	Re-install clamps to proper tension.	___	___	___	___
	Average of above evaluations	___	___	___	___

(*This average is the evaluation for competency U5 "Check and service radiator and heater hoses.")

UNIT II

JOB SHEET #2, LESSON ONE

INSPECT AND SERVICE BELTS

Equipment

New belts, if needed
Belt tension gauge (optional)
Socket set and wrenches

Procedure:

	Evaluation: 3	2	1	N
1. Inspect belts for cracking, splitting, fraying, glazing or oil-soaking.	___	___	___	___
2. Inspect belt tension with hand or proper belt gauging device.	___	___	___	___
3. If belt is too loose or too tight loosen proper adjustment bracket properly adjust tension.	___	___	___	___
(Belt should deflect 1/2-inch along longest interval between pulleys)				
4. If belt must be replaced, loosen proper adjustment bracket(s) and remove belt.	___	___	___	___
5. Replace with correct belt and properly adjust tension.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency U2 "Remove, inspect and replace V-Belts.")

MODULE: MECHANICAL SERVICES

UNIT II: COOLING SYSTEMS

LESSON 2: RADIATOR, THERMOSTAT, WATER PUMP

I. **Radiator and Components**

- A. Radiator
    - 1. Purposes
        - a. To remove heat from engine coolant
        - b. To remove heat from automatic transmission fluid
    - 2. Types
        - a. Downflow (vertical)
        - b. Crossflow (horizontal)
    - 3. Construction (See HO #1.)
        - a. Tanks
        - b. Core tube construction (See HO #2.)
            - i. Tube type
            - ii. Cellular type
        - c. Inlet & Outlet
        - d. Automatic transmission cooler
        - e. Filler neck
    - 4. Operation -- coolant gives up heat to radiator and dissipates into incoming air
    - 5. Methods of repairing radiators
        - a. Solder minor leaks
        - b. Cut and solder leaking tube
        - c. Recore
        - d. Replace
        - e. Chemical stop-leak additive - not recommended
- B. Coolant recovery system (See HO #3.)
    - 1. Purpose

a. To prevent coolant loss when coolant expands

b. Allows more coolant in system

2. Operation

a. Radiator is kept completely full at all times

b. Recovery tank allows room for expansion

c. Coolant is drawn into radiator when it cools and contracts

3. Service Tips

a. Always add coolant to recovery tank

b. Do not remove radiator cap unless necessary

c. Keep coolant recovery hose tight and free of cracks

C. Pressure cap

1. Purpose

a. Keeps system under pressure

b. Allows higher, more efficient operating temperature

2. Operation

a. Increasing system pressure raises coolant boiling point

b. One psi increase = 3° increase in boiling point

(Example: At 15 psi operating pressure, boiling point of plain water will be raised to 257° F. 15 psi x 3° F. = 45° F. increase. 212° F. (boiling point under no pressure) + 45° F. = 257° F.

3. Precautions when removing cap from hot engine

a. Stand to the side of the radiator

b. Always place a rag over cap

c. Loosen cap to safety catch to relieve pressure

4. Procedure for cooling down an overheated engine

a. Shut off engine

b. Raise hood

c. Let engine cool on its own before removing cap

d. Remove cap; start engine and fill with water

II. **Thermostat**

A. Types

1. Pellet - most common (See HO #4)

2. Bellows - air cooled engines mostly (See HO #5.)

B. Functions

1. Regulates engine operating temperature

2. Brings engine to operating temperature quickly

C. Construction (See HO #4.)

1. Pellet-type

a. Pellet

b. Piston

c. Return spring

d. Valve

e. Frame

2. Bellows-type (See HO #5.)

a. Bellows

b. Valve stem

c. Valve

d. Bellows support frame

D. Operation (See HO #4.)

1. Pellet-type

a. Controls coolant circulation

b. Wax in pellet expands

2. Bellows type (See HO #5.)

a. Controls amount of air circulating in air-cooled engine

b. Gas in bellows expands

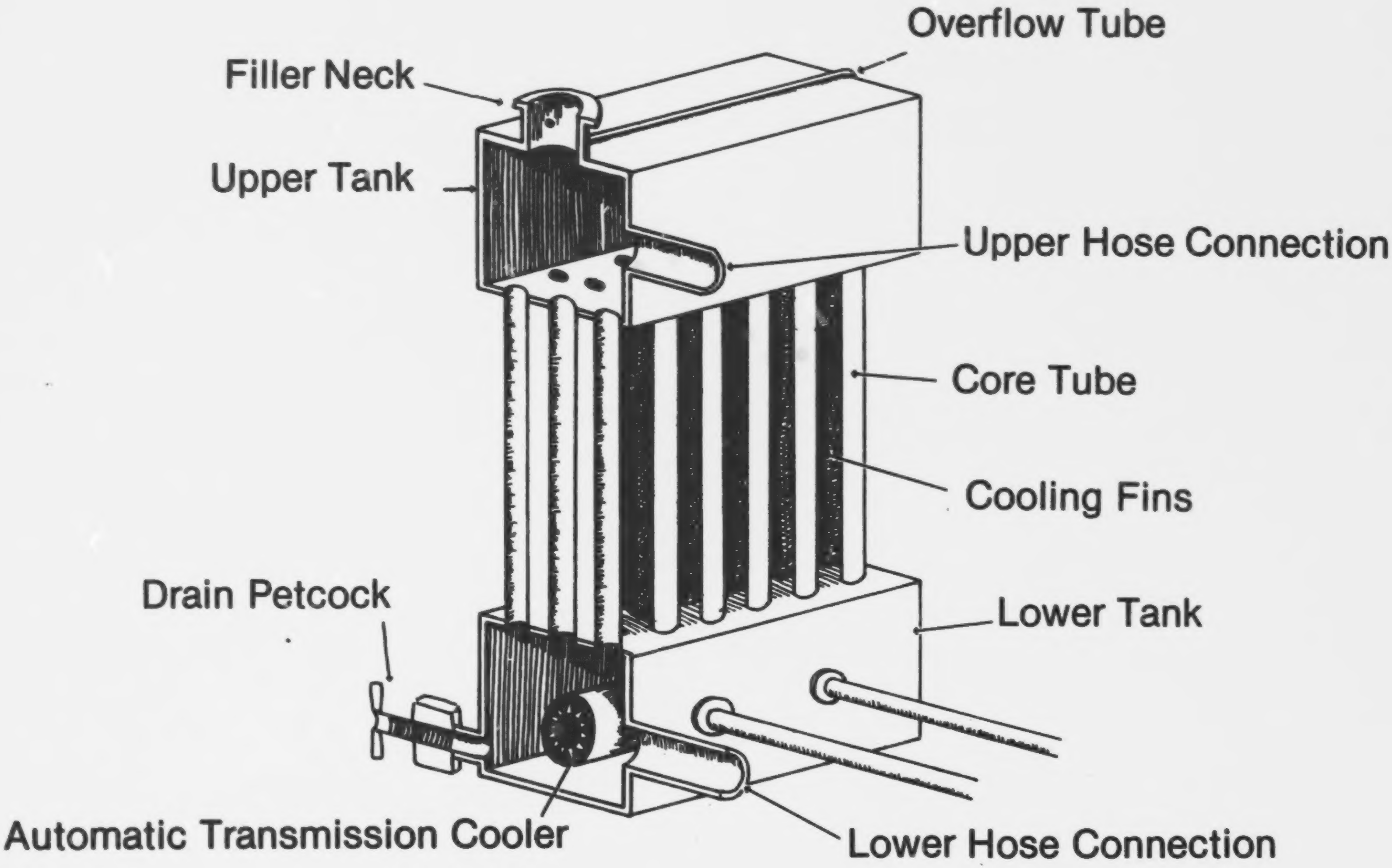
E. Temperature ratings of pellet-type thermostats

1. Most rated between 190 to 195° F.

2. Operating range -- about 20° F.

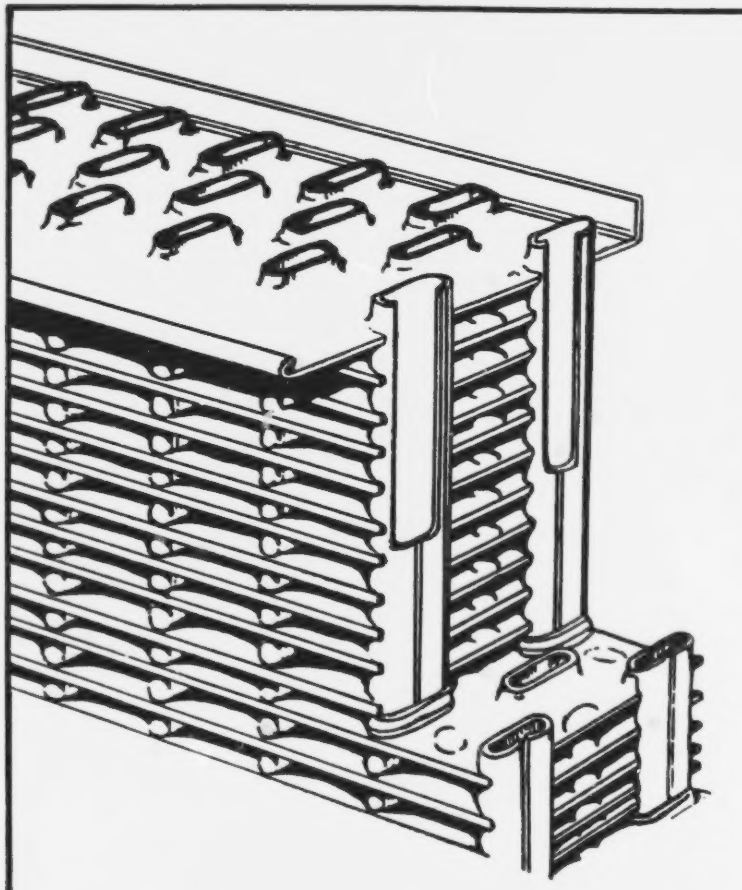
F. Position of thermostat in engine -- pellet must face hot water

Typical Downflow Radiator

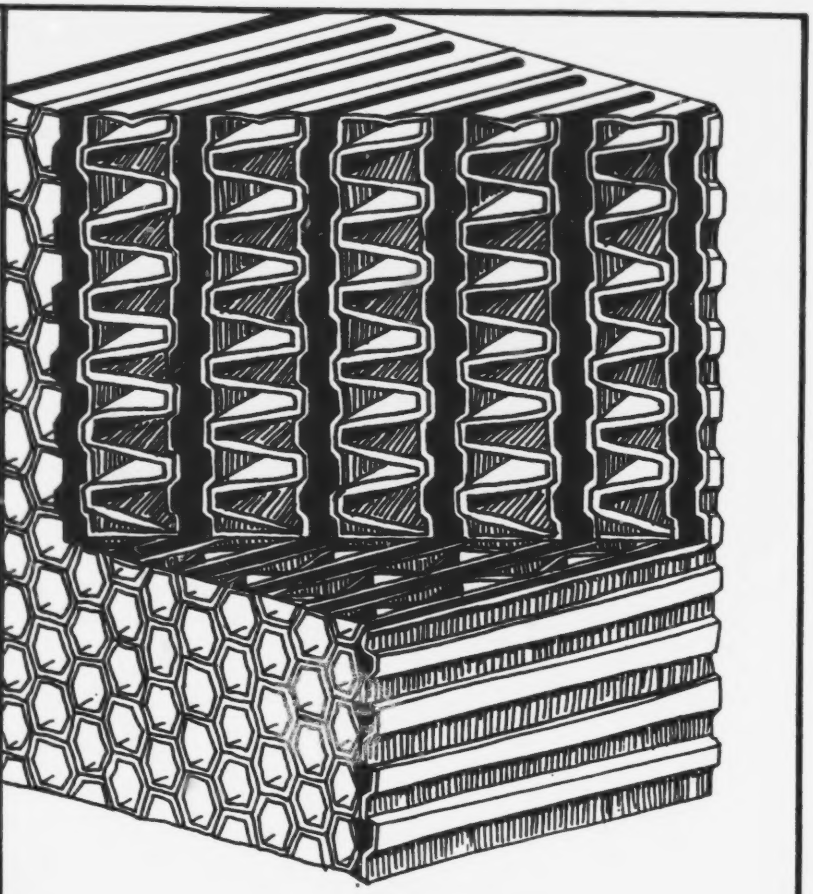

Overflow Tube
Filler Neck
Upper Tank
Upper Hose Connection
Core Tube
Cooling Fins
Drain Petcock
Lower Tank
Automatic Transmission Cooler
Lower Hose Connection

HO 1

Types of Radiator Core Construction



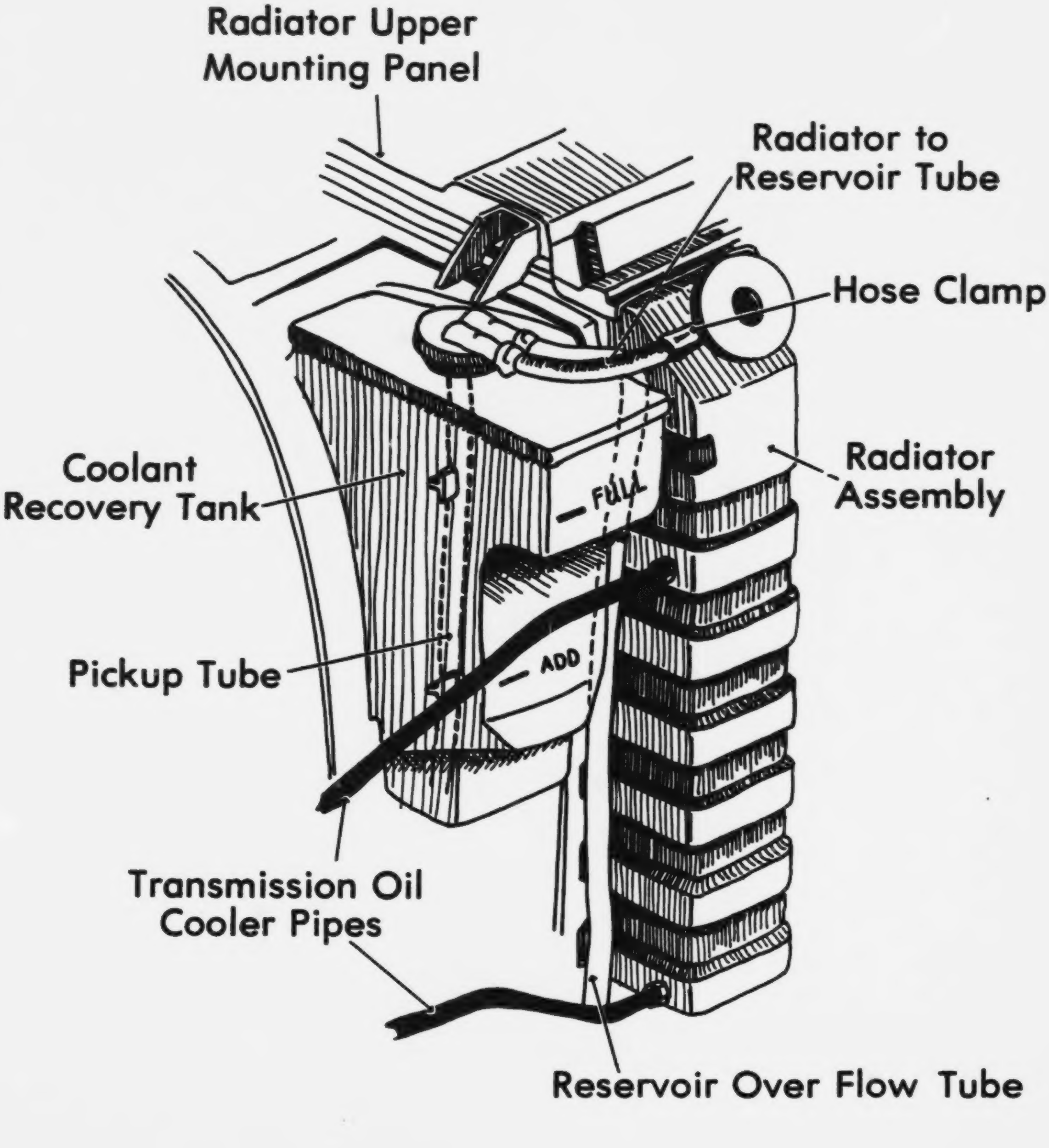
Tube and Fin Type



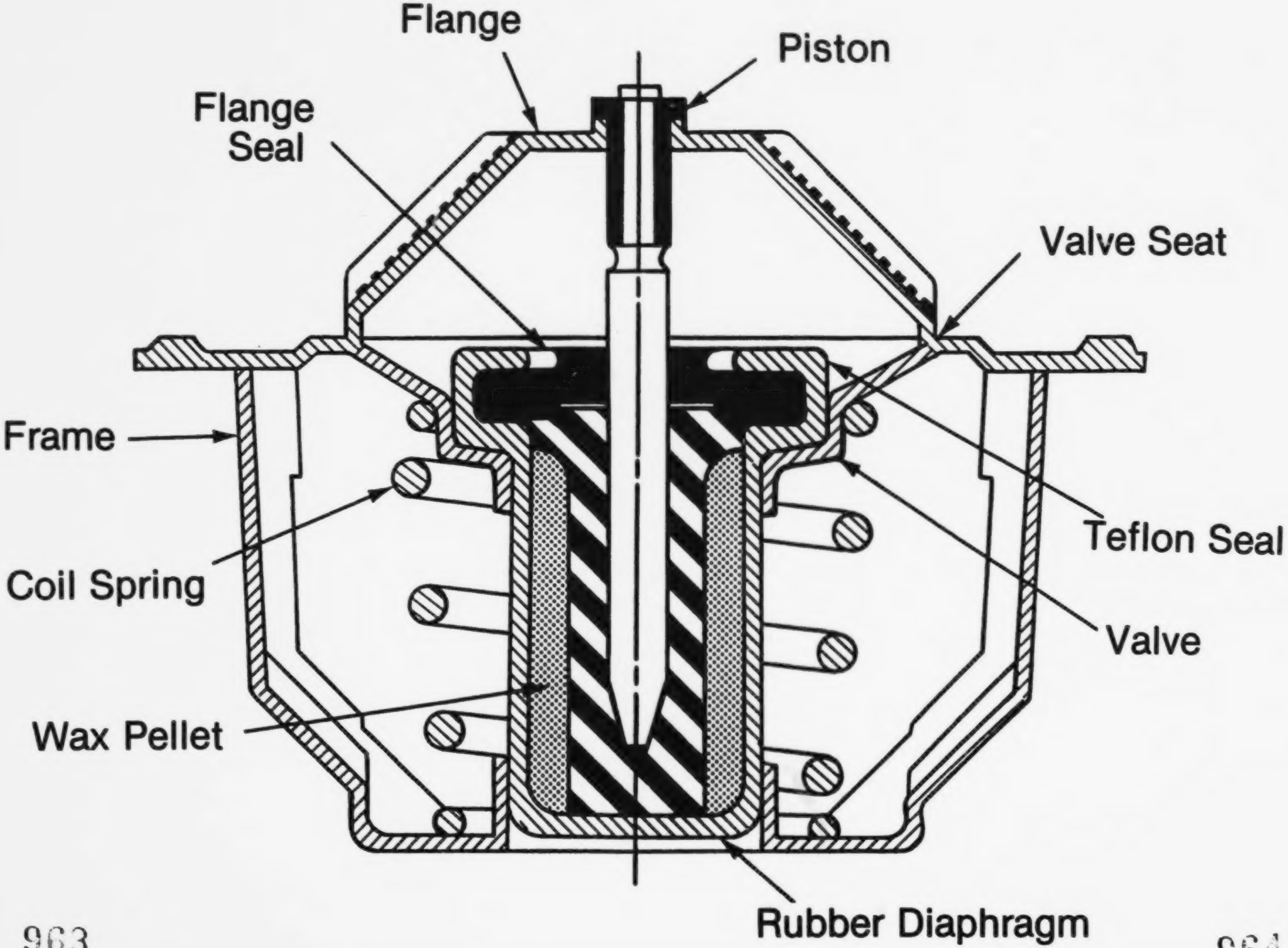
Cellular Type

HO 2

Coolant Recovery System


Radiator Upper Mounting Panel
Radiator to Reservoir Tube
Hose Clamp
Radiator Assembly
Coolant Recovery Tank
FULL
ADD
Pickup Tube
Transmission Oil Cooler Pipes
Reservoir Over Flow Tube

Pellet Type Thermometer

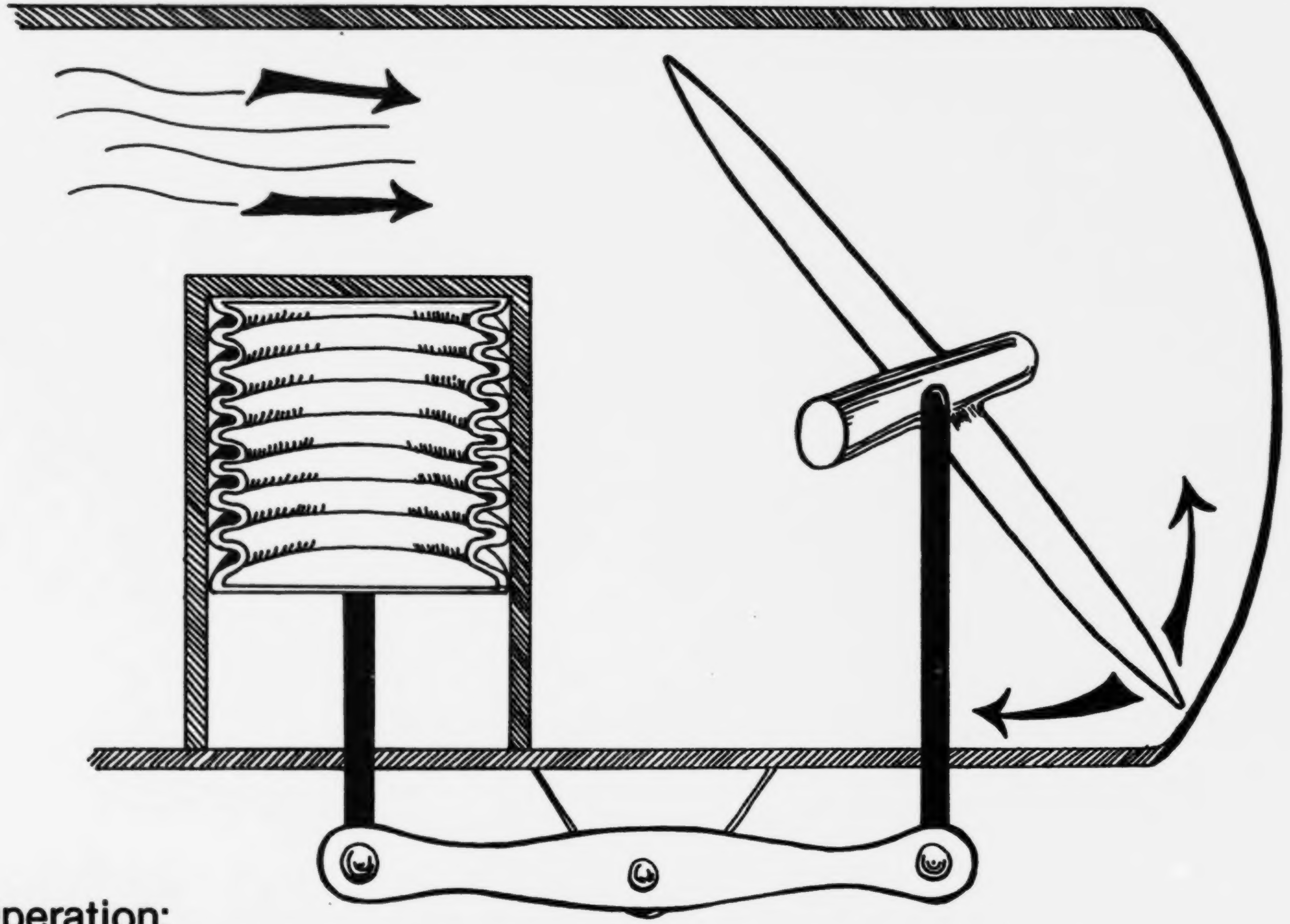


Flange
Piston
Flange Seal
Valve Seat
Frame
Teflon Seal
Coil Spring
Valve
Wax Pellet
Rubber Diaphragm

963

964

Typical Bellows Thermostat



Operation:

A. When thermostat is heated, gas expands causing bellows to stretch.

B. When thermostat cools, gas inside contracts, shrinking thermostat.

HO 5

S-MECH - 67

I-MECH - 103

UNIT II

JOB SHEET #1, LESSON TWO

REMOVE AND REPLACE RADIATOR

Equipment:

Vehicle or test engine
Hose clamp pliers
Screwdriver
Wrenches
Drain pan

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
1. Drain radiator.	___	___	___	___
2. Disconnect upper and lower radiator hoses at the radiator.	___	___	___	___
3. Remove fan shroud screws and move shroud back over fan and water pump.	___	___	___	___
4. Disconnect automatic transmission oil lines from lower part of radiator, if present.	___	___	___	___
(NOTE: Use two wrenches on these fittings to avoid damage to the lines. Always use tubing wrenches on tubing nuts. A drain pan may be needed to catch the transmission fluid that may drain out.)				
5. Remove radiator mounting bolts and lift radiator out.	___	___	___	___
(CAUTION: *Be very careful not to gouge a hole in a core tube. They are very thin and fragile.)*				
6. Check radiator core for excessive dirt and bugs. Check mounting shell for cracks. Use compressed air to blow out dirt and bugs from cooling fins.	___	___	___	___
7. To replace, place radiator in position and put in mounting bolts. Check lower rubber mounting pads for proper positioning, if so equipped and then tighten mounting bolts.	___	___	___	___
8. Replace and tighten automatic transmission oil lines.	___	___	___	___

Procedure: **Evaluation:**
3 2 1 N

9. Move fan shroud into position and insert mounting screws and tighten. ___ ___ ___ ___

10. Reconnect upper and lower radiator hoses. ___ ___ ___ ___

11. Close radiator drain and fill with coolant. ___ ___ ___ ___

    (NOTE: If a petcock is used be careful not to overtighten it – hand tightening is usually sufficient.)

12. Start engine and check for leaks. ___ ___ ___ ___

    (NOTE: Recheck coolant level after engine has thoroughly warmed up. Upper radiator hose will be hot to the touch when thermostat has opened.)

13. Check automatic transmission fluid. Add fluid if needed. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for competency U1 "Remove and replace a radiator.")

MODULE: MECHANICAL SERVICES

UNIT II: COOLING SYSTEMS

LESSON 3: FANS AND COOLANTS

I. **Types of fans (See HO #1.)**

- A. Rigid blade
- B. Flexible blade
- C. Thermo clutch
- D. Electric
- E. Construction and Operation
    - 1. Blade design
        - a. Curved tips - less wind noise
        - b. Uneven spacing - less wind noise
    - 2. Rigid fan
        - a. Blade pitch does not change
        - b. Fan speed controlled by engine speed
    - 3. Flexible blade fan
        - a. Advantage - reduces horsepower losses at high speeds
        - b. Operation - blades flatten out as speed increases, thus reducing drag

II. **Thermo clutch fan (See HO #2.)**

- A. Advantage – reduces horsepower losses and wind noise at high speeds and cool temperatures
- B. Operation of fluid coupling
    - 1. Disengage mode
        - a. Bimetal coil closes the opening between reservoir and working chamber
        - b. Most of silicone fluid stays in reservoir
        - c. Fluid is "wiped" back into reservoir through circulating holes
        - d. Clutch plate "slips," fan free-wheels
    - 2. Engage mode

- a. Bimetal coil is heated by incoming air
- b. Bimetal coil moves shaft and exposes opening from reservoir into working chamber
- c. Fluid fills grooves in working chamber
- d. Clutch plate transmits torque through fluid coupling to clutch housing
- e. Fan speed increases

C. Storage of thermo clutch fan -- store in vertical position to prevent loss of silicone fluid (same position as it is in when on engine).

D. Fan clutch diagnosis

1. Looseness -- up to 1/4-inch lateral movement measured at fan tip is allowable
2. Leakage -- small leaks usually won't affect fan clutch operation
3. Wind noise
    - a. Normal for first few minutes after start up
    - b. Normal when engine is overheated
    - c. Not normal after first few minutes of operation on a cool engine
4. Turning effort
    - a. Should have some drag
    - b. Should not revolve over five times when spun by hand
    - c. Locked-up clutch should be replaced

III. Electric Fan

A. Application

1. Used where engine compartment space is tight
2. Often used on vehicles with transverse engines

B. Operation

1. Thermostatically controlled
2. Driven by electric motor

(**CAUTION:** *Fan may turn on automatically after engine is shut off; so keep hands away from fan blades.)*

IV. Types of antifreeze solutions

- A. Temporary type
    - 1. Ethyl alcohol
    - 2. Methyl alcohol
- B. Permanent type
    - 1. Ethylene glycol
- C. Freezing points of antifreeze
    - 1. Ethyl alcohol = -174.6° F.
    - 2. Methyl alcohol = -144.2° F.
    - 3. Ethylene glycol (68% of solution) = -92° F.
    - 4. Water = 32° F.
- D. Expansion rates, 40° to 180° F.
    - 1. Water -- 1/4 pint/gal.
    - 2. Ethyl alcohol -- 1/2 pint/gal.
    - 3. Methyl alcohol -- 2/5 pint/gal.
    - 4. Ethylene glycol -- 1/3 pint/gal.
- E. Boiling point (solution for protection to -20° F.)
    - 1. Water = 212° F.
    - 2. Ethyl alcohol = 180° F.
    - 3. Methyl alcohol = 180° F.
    - 4. Ethylene glycol* = 223° F.
- F. Advantages of permanent-type antifreeze
    - 1. Not a fire hazard
    - 2. Does not harm car finishes
    - 3. Does not evaporate at normal temperatures
    - 4. Can be left in engine all year
    - 5. Inhibits corrosion

G. Disadvantages of permanent type antifreeze

1. Poisonous if taken internally

2. Damaging to engine bearings and rings if it leaks into crankcase

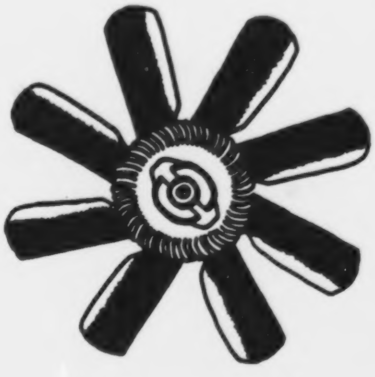
H. Antifreeze-to-water ratio

1. Normally 50/50

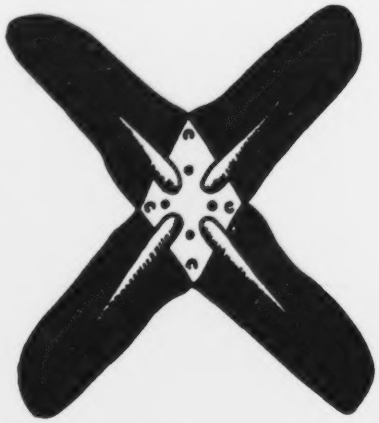
2. Maximum 68% antifreeze protects to -92° F.; more than 68% solution does not increase protection

3. Recommended replacement interval - 24 months.

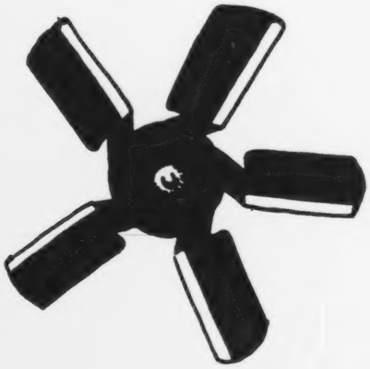
Types of Cooling Fans



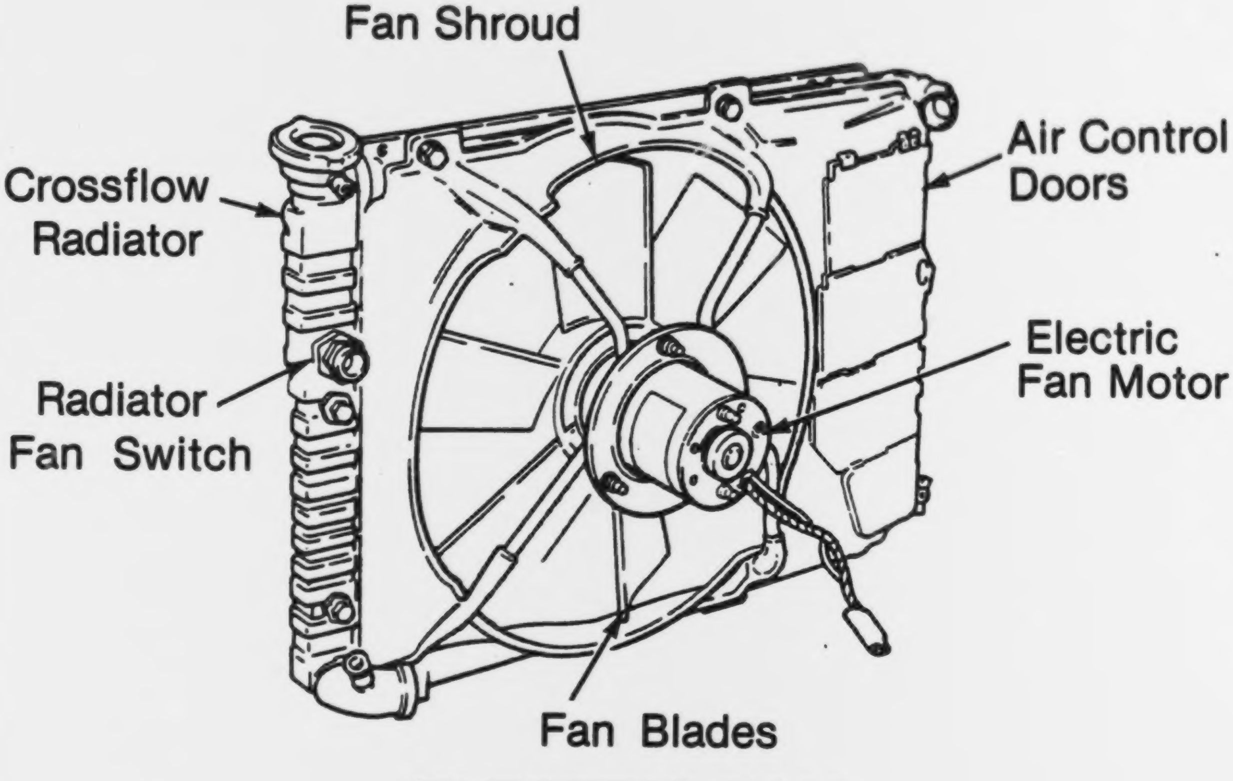
THERMO
CLUTCH FAN



RIGID FAN

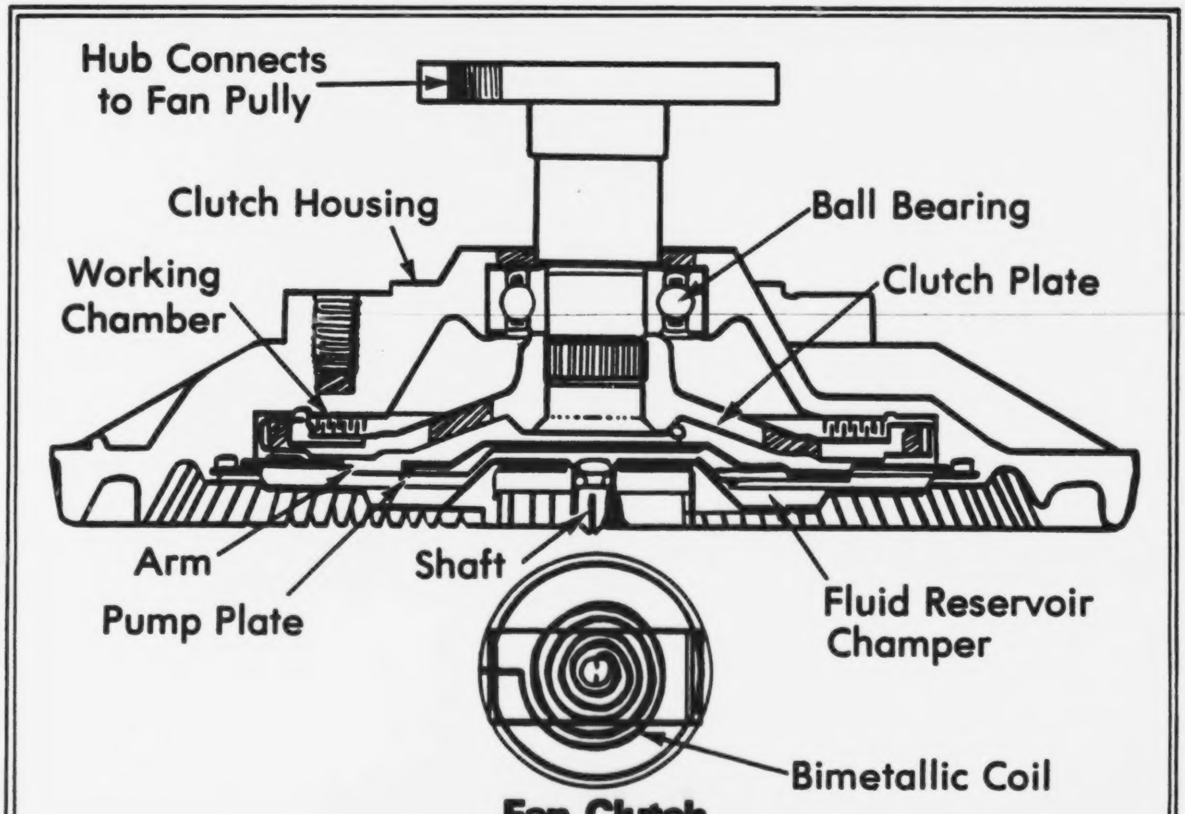


FLEXIBLE
BLADE FAN

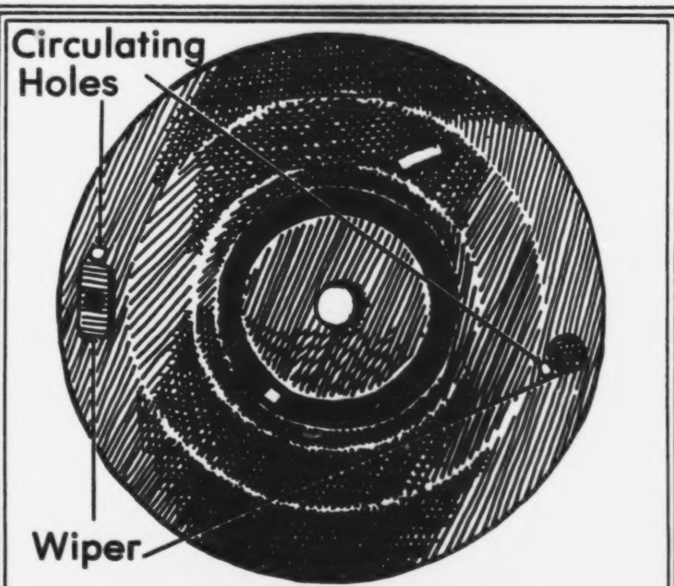

Fan Shroud
Crossflow Radiator
Air Control Doors
Electric Fan Motor
Radiator Fan Switch
Fan Blades

ELECTRIC FAN
MOTOR

Fan Clutch Operation


Hub Connects to Fan Pully
Clutch Housing
Ball Bearing
Working Chamber
Clutch Plate
Arm
Shaft
Pump Plate
Fluid Reservoir Champer
Bimetallic Coil

Fan Clutch


Circulating Holes
Wiper

Fan Clutch Pump Plate

UNIT II

JOB SHEET #1, LESSON THREE

SERVICE FAN BLADES AND CLUTCHES

Equipment:

Wrenches
Screwdrivers

(NOTE: Use a thermo clutch fan for this evaluation.)

Procedure:

		Evaluation: 3	2	1	N
1.	Check for damage to fan blades.	___	___	___	___
2.	Straighten if damage is slight to metal fans.	___	___	___	___
3.	Check for looseness - up to 1/4" lateral movement measured at fan tip is allowable.	___	___	___	___
4.	Check for leakage (small leaks usually won't affect fan clutch operation).	___	___	___	___
5.	Start engine and allow to warm up. Listen for wind noise, which is not normal after a few minutes on a normally running engine.	___	___	___	___
6.	Turn off engine and check turning effort of fan. Fan should have some drag, but should not revolve more than five times when spun by hand.	___	___	___	___
7.	If clutch is locked up, replace fan.	___	___	___	___
8.	If clutch free-wheels too much, check silicone fluid level. Add silicone only according to service manual.	___	___	___	___
	Average of above evaluations*	___	___	___	___

(*This average may be used as the evaluation for competency U4 "Service fan blades and clutches.")

UNIT II

JOB SHEET #2, LESSON THREE

INSPECT AND SERVICE ELECTRICAL FAN MOTORS

Equipment:

Ammeter
Wrenches
Screwdriver

Procedure:	**Evaluation:** 3	2	1	N
1. Connect ammeter to terminals to determine if current is reaching fan motor.	___	___	___	___
2. If current is not reaching motor, troubleshoot electrical system.	___	___	___	___
3. If fan motor is defective, remove fan motor and replace with a fan motor that meets factory specifications.	___	___	___	___
4. Test fan for proper operation by starting car and allowing car to warm up.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average would be the evaluation for an additional competency under duty band U.)

UNIT II

JOB SHEET #3, LESSON THREE

TEST ANTIFREEZE SOLUTION

Equipment:

Vehicle or test engine
Antifreeze hydrometer
Antifreeze
Drain pan

(NOTE: Do not remove radiator pressure cap from a coolant recovery system. Check coolant level in the coolant recovery tank.)

Procedure: **Evaluation:**
3 2 1 N

1. Start engine and bring engine to operating temperature and remove radiator cap, if necessary. ___ ___ ___ ___

   (**CAUTION:** *Loosen cap to first stop to release pressure, then remove cap.)*

2. Place antifreeze hydrometer tube in coolant and draw coolant into tester several times to equalize temperature of all parts, then read the number on the float at liquid level. ___ ___ ___ ___

   (NOTE: The temperature should also be checked and a chart for temperature correction should be consulted.)

3. Calculate amount of antifreeze needed if freezing point is not low enough. (Freezing point of coolant should be about 10° F below lowest expected temperature). ___ ___ ___ ___

   (NOTE: To calculate antifreeze needs, determine cooling system capacity from auto repair manual and refer to chart on antifreeze container).

4. Drain enough coolant from cooling system to accommodate full amount of antifreeze needed to add and pour in additional antifreeze. ___ ___ ___ ___

   (NOTE: Leave 2 inches for expansion if no coolant recovery system is used. Fill to top if coolant recovery system is used. Fill coolant recovery tank to the "cold level".)

Procedure:	**Evaluation:** **3**	**2**	**1**	**N**
5. Install pressure cap, if removed, and start engine and bring to normal operating temperature.	___	___	___	___
6. Retest antifreeze freezing point.	___	___	___	___
7. Recheck coolant level and adjust as needed.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency U3 "Test antifreeze solution.")

MODULE: MECHANICAL SERVICES

UNIT II: ENGINE COOLING SYSTEMS

UNIT TEST

I. Match the terms in the left column with the most closely associated definition in the right column.

_____1. Any liquid circulated through a cooling system

_____2. Surrounds fan

_____3. Passage through block

_____4. Plastic tank

_____5. Regulates engine heat

_____6. Forces air through radiator

_____7. Closes cooling system

_____8. Circulates coolant

_____9. Used when thermostat closed

_____10. Allows air to pass over coolant

A. Coolant recovery system

B. Fan

C. Water by-pass

D. Radiator core

E. Transfer agent

AB. Water jacket

AC. Water pump

AD. Coolant

AE. Pressure cap

BC. Shroud

BD. Thermostat

II. Use the correct letter from the diagram to identify the named components.

_____11. Fan

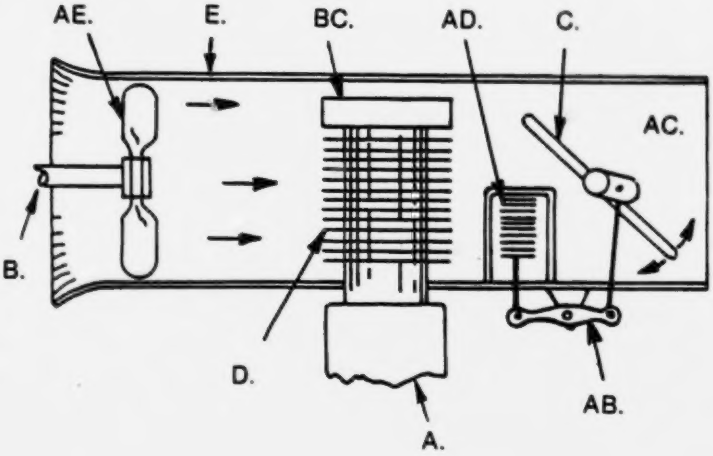
_____12. Shroud

_____13. Thermostat

_____14. Butterfly valve

_____15. Cooling fins

_____16. Linkage



III. Use the correct letter from the diagram to identify the named components.

_____17. Pressure cap

_____18. Water by-pass

_____19. Thermostat

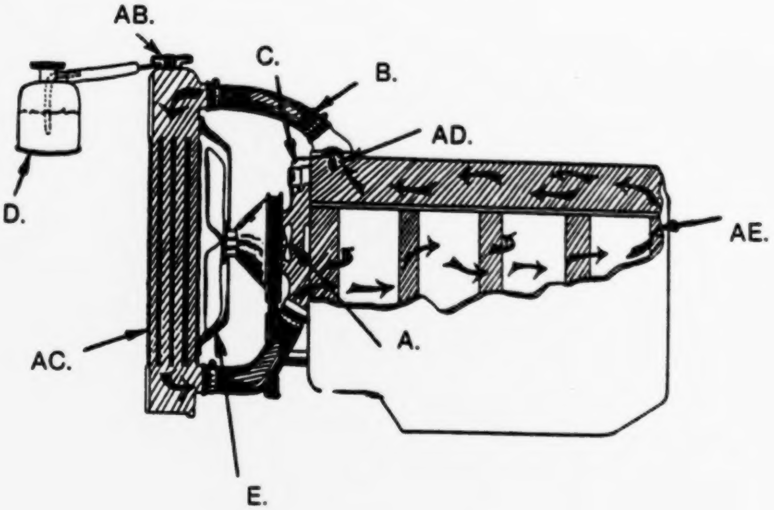
_____20. Recovery tank

_____21. Water jackets

_____22. Radiator

_____23. Water pump

_____24. Shroud



IV. Use the correct letter from the diagram to identify the named components.

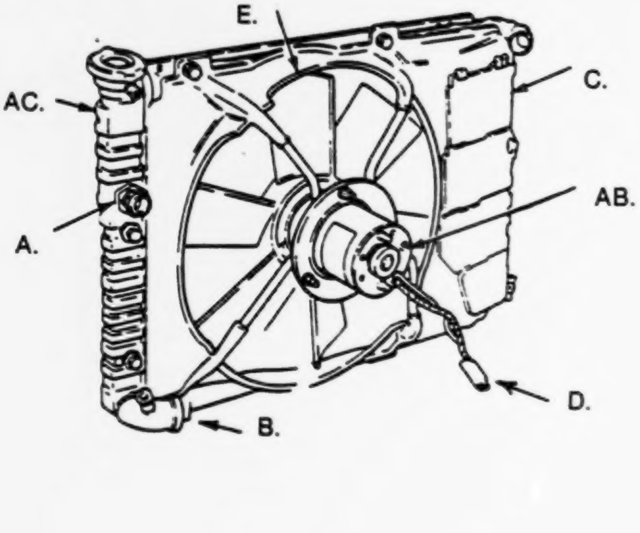
_____25. Radiator

_____26. Shroud

_____27. Air control doors

_____28. Fan switch

_____29. Motor



V. Select the best answer from the choices listed

_____30. When firm pressure is applied at the longest interval between pulleys, a belt should deflect: (a) no more that 1/16 inch, (b) 1/4 inch, (c) 1/2 inch, (d) 3/4 inch, (e) 1 inch.

_____31. A smell of antifreeze inside the car combined with fogging of the windows is a sign of: (a) a cracked head, (b) a broken radiator hose, (c) heater core leakage, (d) a broken temperature-sending unit, (e) too much antifreeze.

_____32. The heater is connected to the cooling system because: (a) it helps the engine warm up, (b) it needs heated coolant to operate, (c) it helps the engine cool off, (d) it keeps antifreeze clean, (e) the heater is in the radiator.

_____33. On vehicles with a coolant recovery system, coolant should be added: (a) Through the pressure cap when the engine is cold, (b) through the pressure cap when the engine is hot, (c) through the recovery tank when the engine is cold, (d) through the recovery tank when the engine is hot, (e) through the recovery tank when the engine is hot or cold).

_____34. In storing a thermo clutch fan, the fan should be stored: (a) in a cool area, (b) in a warm area, (c) wrapped up in a rag, (d) in a horizontal position, (e) in a vertical position.

_____35. Caution should be exercised around electric fan motors because: (a) they can turn on even when the engine is off, (b) they can produce an electric shock, (c) they are very hot after they have been in operation, (d) they contain a poisonous gas, (e) they have razor-sharp blades.

_____36. The maximum protection afforded by ethylene glycol is: (a) -32° F, (b) -68° F, (c) -92° F, (d) -144.2° F, (e) -174.6° F.

(NOTE: Completion of this unit test with a minimum score of ________ is necessary for the student to receive an evaluation for competencies U1-U5.)

ANSWERS TO UNIT II TEST

1. AD
2. BC
3. AB
4. A
5. BD
6. B
7. AE
8. AC
9. C
10. D

11. AE
12. E
13. AD
14. C
15. D
16. AB

17. AB
18. C
19. AD
20. D
21. AE
22. AC
23. A
24. E

25. AC
26. E
27. C
28. A
29. AB

30. (c)
31. (c)
32. (b)
33. (e)
34. (e)
35. (a)
36. (c)

MODULE: MECHANICAL SERVICES

UNIT III: AIR CONDITIONING SYSTEMS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify vehicle air conditioning systems, repair and replace air conditioning system components and discharge, evacuate and charge air conditioning systems. Mastery will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Match terms with their definitions or illustrations (Competency V1, Unit III test)

II. Identify the functions of the air conditioning system and its components (Competency V1, Unit III test)

III. Identify operations of components (Competency V1, Unit III test)

IV. Identify methods of controlling temperature (Competency V1, Unit III test)

V. Identify high- and low-pressure components (Competency V1, Unit III test)

VI. Identify CCOT system (Competency V1, Unit III test)

Lesson 2:

I. Identify the functions of the manifold gauge (Competency V1, Unit III test)

II. Identify service valves (Competency V1, Unit III test)

III. Identify safety procedures related to servicing air conditioning systems (Competency V1, Unit III test)

IV. Demonstrate the ability to:

   a. Test system for leaks (Competency V4, JS#1)

   b. Evacuate and charge system using vacuum pump (Competency V6, JS#2)

   c. Remove and replace a condenser (Competency V2, JS#3)

   d. Remove and re-install compressor (Competency V3, JS#4)

   e. Repair leaks in air conditioning system (Competency V5, JS#5)

   f. Check and service air conditioning hoses (Competency V7, JS#5)

MODULE: MECHANICAL SERVICES

UNIT III: AIR CONDITIONING SYSTEMS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Notes to the instructor

C. References

D. Lesson plans

1. Lesson 1: Principles of Air Conditioning Systems

    a. Information outline

    b. Handouts

        HO#1: Basic refrigeration cycle
        HO#2: High and low sides of a refrigeration system
        HO#3: General Motors CCOT system

2. Lesson 2: Servicing Air Conditioning Systems

    a. Information outline

    b. Handouts

        HO#1: Manifold gauge set
        HO#2: Manifold hand valve positions
        HO#3: Service valves
        HO#4: Purging the charging hoses of air
        HO#5: Discharging the system
        HO#6: Evacuating the system

    c. Job sheets

        JS#1: Test system for leaks
        JS#2: Evacuate and charge system
        JS#3: Remove and replace a condenser
        JS#4: Remove and re-install compressor
        JS#5: Repair leaks in air conditioning system and check and service air conditioning hoses

E. Unit test

F. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Due to this unit receiving a low priority, the information presented is not as thorough as in the bulk of the material in this curriculum. For that reason, supplemental material will have to be used for students to gain a better understanding. The units in this module are not as suitable as material in the other modules for independent study by the student.

REFERENCES USED IN WRITING THIS UNIT

1. Crouse, William H. *Automotive Mechanics*. Eighth edition. McGraw-Hill. St. Louis, MO. 1980.

2. Dwiggins, Boyce H. *Automotive Air Conditioning*. Fourth edition. Delmar Publishers, Albany, NY.

3. Gaines, Jim. Auto Mechanics. *Automotive Accessories: Air Conditioning, Spaed Control and Service Procedures*. Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1981.

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MODULE: MECHANICAL SERVICES

UNIT III: AIR CONDITIONING SYSTEMS

LESSON 1: PRINCIPLES OF AIR CONDITIONING SYSTEMS

I. **Terms and definitions**

- A. Boiling point -- The temperature at which a liquid changes to a gas.
- B. Charge -- Adding fresh refrigerant and refrigerant oil to an air-conditioning system.
- C. Desiccant -- Drying agent used in air-conditioning systems to absorb moisture.
- D. Discharge -- Removing some or all of the refrigerant from an air-conditioning system.
- E. Evacuate -- Removing air and moisture from an air conditioning system after it has been discharged.
- F. R-12 -- The refrigerant used in automotive air-conditioning systems. It changes from liquid to gas at -21.6° F.
- G. Refrigerant -- A substance that cools by removing heat through the process of evaporation.
- H. Refrigerant oil -- A special moisture-free oil used in air-conditioning systems.
- I. Refrigeration -- The process of removing heat by evaporation.

II. **Functions of air conditioning system**

- A. Cool (remove heat)
- B. Clean (remove dust and pollen)
- C. Dehumidify (remove moisture)
- D. Circulate the air
- E. Basic refrigeration cycle (See HO #1.)
  - 1. Compressor
  - 2. Condenser
  - 3. Receiver-drier
  - 4. Thermostatic expansion valve
  - 5. Evaporator

III. **Operation of mechanical components**

- A. Compressor

1. Purposes
    a. Raises pressure and temperature of R-12 so it is hotter than outside air
    b. Circulates R-12 through system
2. Construction
    a. Low side (suction) - connected to evaporator
    b. High side (pressure) - connected to condenser
    c. Axial, radial and reciprocating types
    d. Magnetic clutch
3. Location
    a. Mounted on engine
    b. Belt -- driven by crankshaft
4. Operation
    a. Low pressure, low temperature R-12 -- gas enters from evaporator.
    b. R-12 is compressed to a high pressure, high temperature gas.
    c. R-12 is forced into condenser to be cooled and condensed.
5. Lubrication
    a. Refrigerant oil is circulated with R-12.
    b. Sump in compressor holds extra refrigerant oil.
    c. Never use motor oil.
    d. Do not use refrigerant oil again, as it becomes contaminated by moisture.

B. Condenser

1. Purpose
    a. Remove heat from R-12 which was absorbed from evaporator.
    b. Condense R-12 into a liquid.
2. Construction
    a. Tube and fin; similar to radiator
    b. Inlet -- top of condenser
    c. Outlet -- bottom of condenser

3. Location -- mounted in front of radiator
4. Operation
    a. High-pressure, high-temperature R-12; gas enters top of condenser.
    b. Air passing through condenser is cooler than R-12 inside condenser.
    c. Heat from R-12 is absorbed by incoming air.
    d. R-12 loses enough heat to condense to a liquid.
    e. R-12 leaves condenser as a high-pressure, high-temperature liquid.

C. Receiver-drier
1. Purposes
    a. Stores liquid refrigerant
    b. Removes moisture from R-12
    c. Filters dirt particles
2. Construction
    a. Steel cylinder with inlet and outlet ports
    b. Desiccant (drying agent)
    c. Sight glass (sometimes used)
3. Location
    a. Between condenser outlet and expansion valve
    b. Usually mounted next to condenser
4. Operation
    a. R-12 enters receiver and passes over the desiccant
    b. Liquid R-12 is stored in receiver
    c. R-12 is taken from the bottom of receiver to insure it is in liquid state

D. Sight glass (not used on some systems)
1. Purpose is to observe R-12 to check for bubbles. This is an indication of amount of refrigerant in system.
2. Locations
    a. On receiver-drier

   b. In refrigerant line between receiver-drier and expansion valve

  3. Operation

   a. As R-12 passes under sight glass, it will normally not show bubbles when compressor is pumping and system is sufficiently charged.

   b. Bubbles in sight glass with compressor pumping normally indicates a low charge of R-12.

   (NOTE: On systems using a suction-throttling valve (POA valve) to control evaporator icing, some bubbling and foaming are normal. Some systems of this type do not use a sight glass to avoid confusion.)

E. Typical Expansion Valve (TXV)

  1. Purpose

   a. Drops the pressure resulting in temperature drop of liquid R-12 before entering evaporator.

   b. Regulates proper amount of liquid R-12 entering evaporator for efficient cooling.

  2. Construction

   a. Metal housing

   b. Diaphragm

   c. Valve and seat

   d. Capillary tube

   e. Equalizer line

  3. Location - Inlet side of evaporator

  4. Operation

   a. As temperature of evaporator R-12 increases, TXV opens to allow more R-12 liquid to enter.

   b. As temperature of evaporator R-12 decreases, TXV closes to restrict entry of R-12 into evaporator.

F. Evaporator

  1. Purposes

   a. Removes heat from passenger compartment

   b. Removes moisture from passenger compartment

   c. Removes dust and pollen from passenger compartment

2. Construction

   a. Tubes and fins

   b. Similar to a radiator

   c. Inlet at bottom

   d. Outlet at top

   e. Smaller in size than condenser

3. Location

   a. Factory units -- in heater housing on firewall

   b. Hang-on units -- under dash

4. Operation

   a. R-12 enters bottom of evaporator as a low- pressure, low-temperature liquid.

   b. Warm air from passenger compartment is forced over the evaporator.

   c. R-12 absorbs heat from the evaporator tubes and fins and changes to a gas.

   d. As air is blown over evaporator it gives up some of its heat and comes back into passenger compartment as cooled air.

   e. As warm air contacts cold evaporator, enough heat is removed to cause moisture to condense on evaporator surface. Moisture is then drained outside car.

   f. Dust and pollen are trapped by moisture sticking to outside of evaporator.

IV. Methods of controlling evaporator temperature

A. Purpose -- prevents water condensate from freezing on outside of evaporator by keeping evaporator temperature above 32° F.

B. Evaporator pressure control valves

1. Pilot-Operated Absolute Suction Throttling Valve (POA valve) (See HO #2.)

   a. Application -- General Motors (before 1973)

   b. Location -- in low-pressure line at evaporator outlet

2. Valves in Receiver (VIR)

   a. Application -- General Motors 1973-1976

   b. Location -- next to air conditioner housing

3. Evaporator Pressure Regulator (EPR)

   a. Application -- Chrysler Corporation cars

   b. Location -- built into back of compressor at compressor inlet

4. Operation -- Valve opens to allow more R-12 to enter compressor when evaporator pressure drops below pre-set level (22 to 30 psi).

C. Cycling clutch system

   1. Application -- various manufacturers

   2. Operation

      a. Thermostat senses evaporator temperature.

      b. When evaporator temperature drops, thermostat turns off magnetic clutch to stop compressor pumping.

      c. When evaporator temperature rises above pre-set temperature, thermostat turns on compressor magnetic clutch.

V. High- and low-pressure components

A. High-pressure side components (See HO #2.)

   1. Compressor discharge and discharge hose

   2. Condenser

   3. Receiver-drier

   4. Liquid line from condenser to expansion valve

   5. Inlet half of expansion valve

B. Low-pressure side component (See HO #2.)

   1. Outlet half of expansion valve

   2. Evaporator

   3. Evaporator inlet and outlet hoses

   4. Accumulator (if used)

   5. Suction (inlet) side of compressor

VI. Cycling Clutch Orifice Tube (CCOT System)

A. Description of system (See HO #3.)

B. Some components differ from conventional systems

C. Expansion tube instead of expansion valve

  1. Purpose -- same as expansion valve

  2. Construction

    a. Sintered bronze filter

    b. Fixed orifice (opening)

  3. Location -- inlet line to evaporator

  4. Operation -- orifice tube drops pressure of R-12 and meters R-12 into evaporator

D. Accumulator (no receiver-drier on high side)

  1. Purpose

    a. Separates R-12 vapor from R-12 liquid to prevent liquid

    b. Removes moisture

  2. Construction

    a. Metal cylinder

    b. Inlet and outlet ports

    c. Desiccant (drying agent)

  3. Location -- in the outlet pipe of the evaporator

  4. Operation

    a. Vapor R-12 and some liquid R-12 enter accumulator from the evaporator.

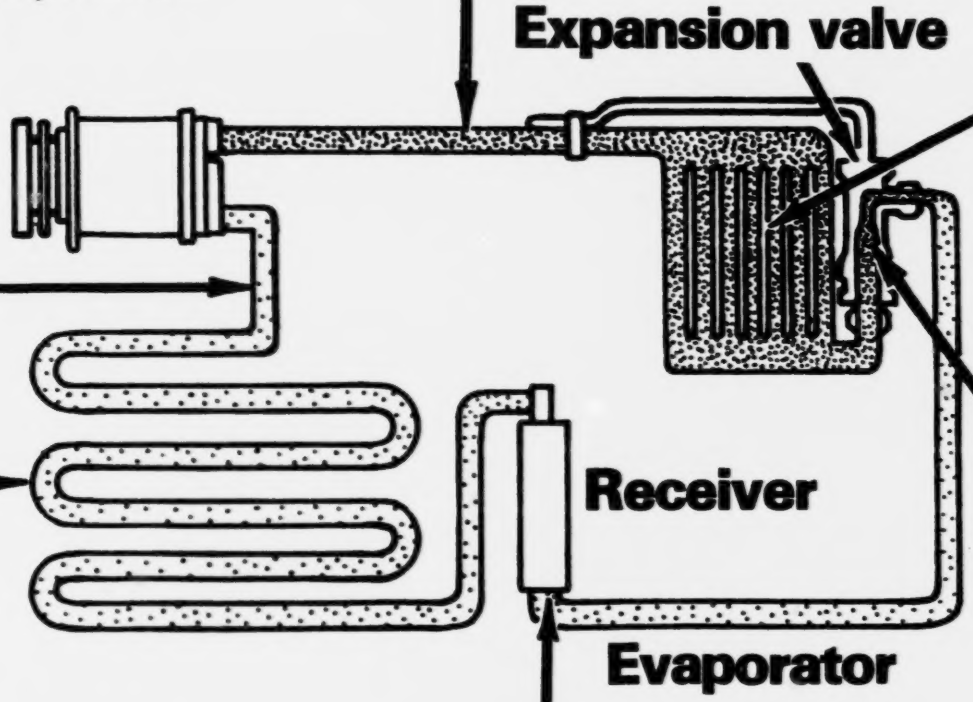
    b. Liquid R-12 falls to bottom and moisture is removed.

    c. Vapor R-12 is removed from top of accumulator and sucked into compressor.

Basic Refrigeration Cycle

① Refrigerant leaves compressor as a high pressure-high temperature vapor.

⑥ Refrigerant returns to compressor as low pressure vapor.



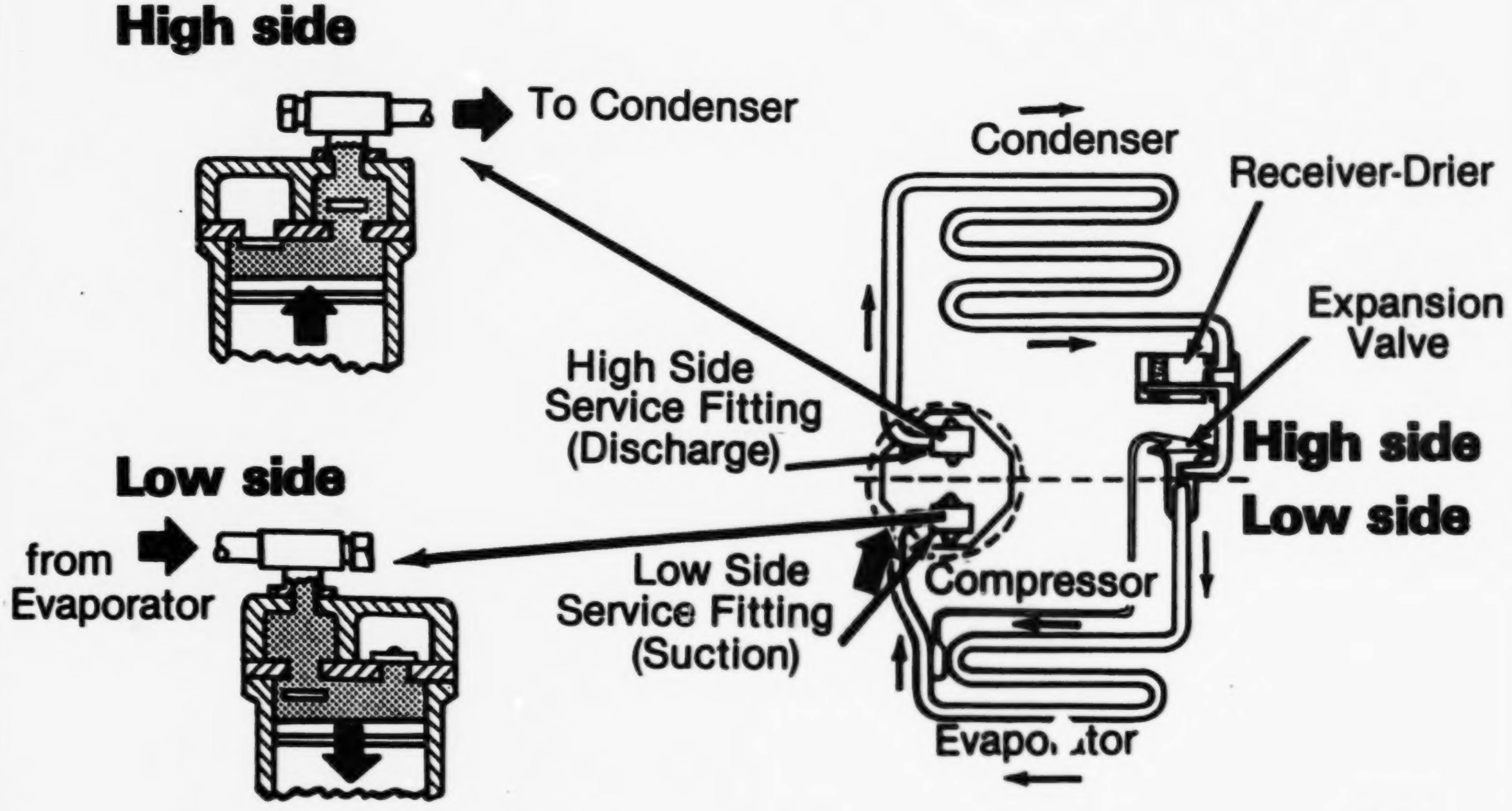
⑤ Heat removed from air entering vehicle vaporizes low pressure liquid refrigerant.

④ High pressure liquid changes to low pressure liquid at this point.

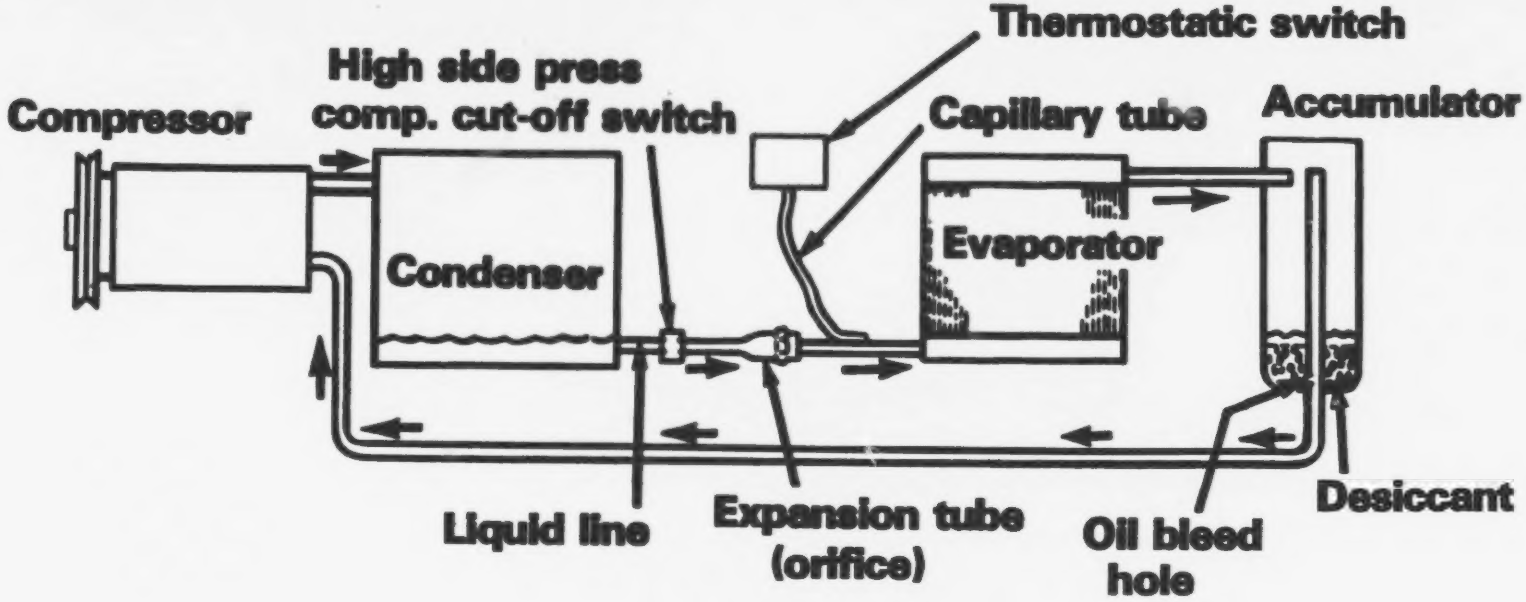
② Upon removal of heat, vapor becomes high pressure liquid refrigerant.

③ Liquid refrigerant is stored here until needed.

High and Low Sides of a Refrigeration System


High side
To Condenser
Condenser
Receiver-Drier
Expansion Valve
High Side Service Fitting (Discharge)
High side
Low side
Low side
from Evaporator
Low Side Service Fitting (Suction)
Compressor
Evaporator

General Motors Cycling Clutch Orifice Tube(CCOT)System


Thermostatic switch
High side press comp. cut-off switch
Compressor
Capillary tube
Accumulator
Evaporator
Condenser
Desiccant
Liquid line
Expansion tube (orifice)
Oil bleed hole

Expansion Tube - Replaces thermostatic expansion valve but performs same function.

Accumulator - Replaces Receiver-Drier. Separates vapor R-12 from liquid R-12 and stores some liquid R-12. Removes moisture from R-12. Located on low side of system.

Thermostat - Replaces POA valve. Cycles compressor to prevent evaporator temperature from dropping low enough to freeze water condensate.

MODULE: MECHANICAL SERVICES

UNIT III: AIR CONDITIONING SYSTEMS

LESSON 2: SERVICING AIR CONDITIONING SYSTEMS

I. **Manifold gauge set**

  A. Purposes

    1. Measure system pressures

    2. Charge and evacuate system

  B. Types

    1. Single gauge

    2. Two-gauge set

    3. Three-gauge set

  C. Parts of the manifold gauge set (See HO #1.)

    1. Manifold

      a. Contains fittings for hose and gauges

      b. Contains hand shut-off valves

    2. Hand shut-off valve positions (See HO #2.)

      a. Closed (clockwise) -- gauge shows pressure but no R-12 passes through manifold.

      b. Open (counterclockwise) -- gauge shows pressure and R-12 may pass through manifold.

    3. Low side gauge

      a. Compound gauge -- measures both vacuum and pressure.

      b. Typical pressure scale -- 0 to 150 psi (pounds per square inch gauge)

      c. Vacuum scale -- 0 to 30 inches Hg (mercury)

      d. Protected up to 250 psi in case of reverse hookup

      e. Blue in color

    4. High side gauge

      a. Typical pressure range -- 0 to 500 psi

      b. Red in color

5. Third gauge (when used)
   a. Used to measure pressure drop across an evaporator pressure control device
   b. Used in low pressure side
   c. Typical pressure range -- 0 to 150 psi
6. Hoses
   a. Blue -- low side
   b. Red -- high side
   c. White or yellow -- center port for connecting refrigerant container
7. Fittings
   a. Replaceable gaskets
   b. Built-in pin for depressing service valve
   c. Different sizes for low and high side on some systems to prevent improper hookup

II. **Types of service valves**

A. Purpose -- to allow system to be charged and evacuated

B. Hand shut-off type (See HO #3.)

1. Location -- on compressor
2. Valve positions
   a. Front seated (clockwise) -- R-12 flow is shut off. Used to isolate compressor
   b. Back seated (counterclockwise) -- Gauge port is out of system. Normal operating position
   c. Mid-position -- R-12 will flow through system and gauge will read pressure. Used for charging and evacuating
   d. Cracked (slightly opened from back-seated operating position) -- used for taking pressure readings

C. Schrader type (See HO #3.)

1. Location
   a. Low side -- between evaporator outlet and compressor inlet
   b. High side -- between compressor discharge and condenser inlet

  2. Valve positions
     a. Open – service hose connected
     b. Closed – service hose not connected

D. Connecting the manifold gauge set into system for servicing
  1. Purging the charging hoses of air (See HO #4.)
  2. Discharging the system (See HO #5.)
  3. Evacuating the system with a vacuum pump (See HO #6.)

E. Halide leak detector
  1. When exposed to refrigerant, a color change will occur in the flame above the reactor plate in the leak detector.
     a. Pale blue – no refrigerant loss
     b. Pale yellow – very small refrigerant loss at edge of the flame
     c. Yellow – small refrigerant loss
     d. Purplish-blue – large refrigerant loss
     e. Violet – heavy refrigerant loss

III. SAFETY

(NOTE: Safety is extremely important in working with air conditioning system).

A. Always wear safety goggles when opening refrigerant-12 lines.

B. Do not weld or steam clean on or near the air conditioning system or discharge vapor into area where flame is exposed.

C. Do not expose eyes to liquid.

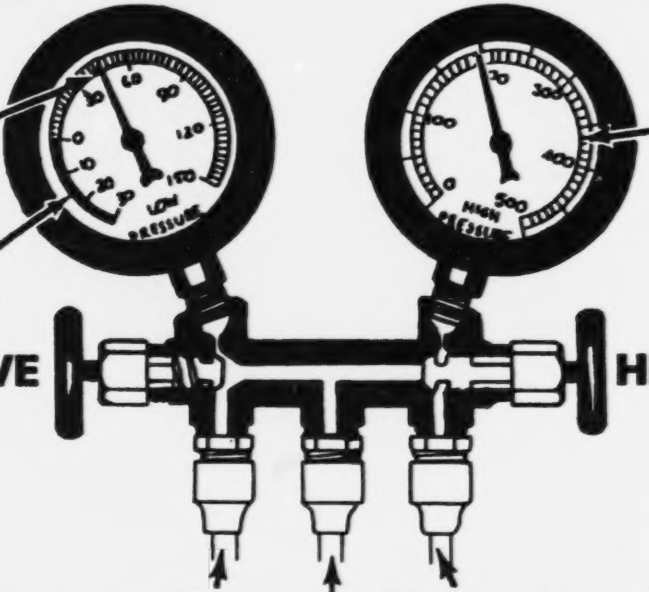
D. Avoid breathing smoke and fumes produced by the burning of the refrigerant-12. Such fumes may be hazardous.

E. If refrigerant-12 should strike the eyes, call a doctor immediately. In the meantime:
  1. Do not rub the eye. Splash the affected area with quantities of COLD water to gradually get the temperature above the freezing point.
  2. Apply an antiseptic oil, which is helpful in providing a protective film over the eyeball to reduce the possibility of infection.

F. Should refrigerant-12 come into contact with the skin, treat the same as skin which has been frostbitten or frozen.

G. Even if all refrigerant has been removed from system, proceed cautiously, regardless of gauge readings. Open very slowly, keeping face and hands away so that no injury can occur.

Manifold Gauge Set



LOW SIDE GAUGE

HIGH SIDE GAUGE

Pressure (PSIG)
(Kg/cm^2)

Vacuum
(Inches of Vacuum)

Pressure (PSIG)
(Kg/cm^2)

LOW SIDE HAND VALVE

HIGH SIDE HAND VALVE

Refrigerant from Low Side

Refrigerant from High Side

Charging and Purging Hose

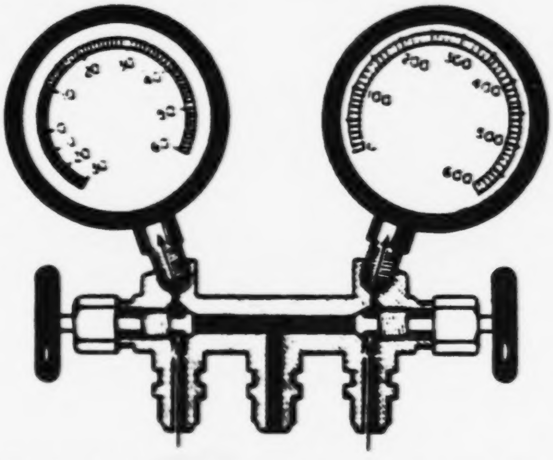
LOW PRESSURE SIDE

Low Side Gauge
Manifold
Low Side Hand Valve
Low Side Test Hose

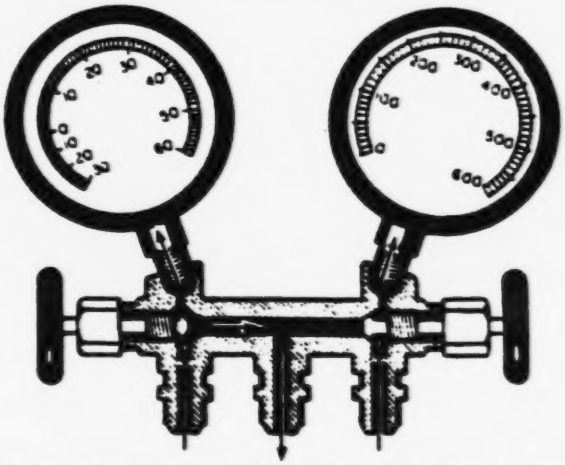
HIGH PRESSURE SIDE

High Side Gauge
Manifold
High Side Hand Valve
High Side Test Hose

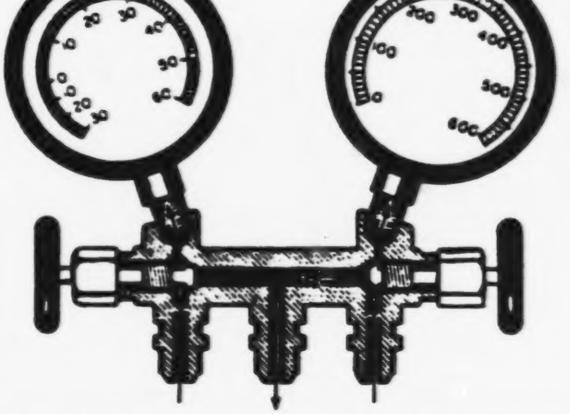
Manifold Hand Valve Positions



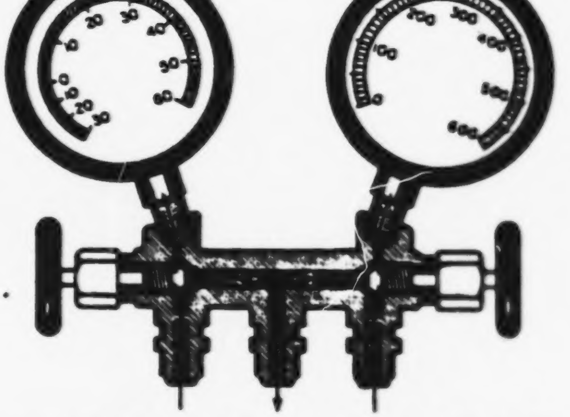
BOTH HAND VALVES CLOSED



LOW SIDE HAND VALVE OPEN,
HIGH SIDE CLOSED

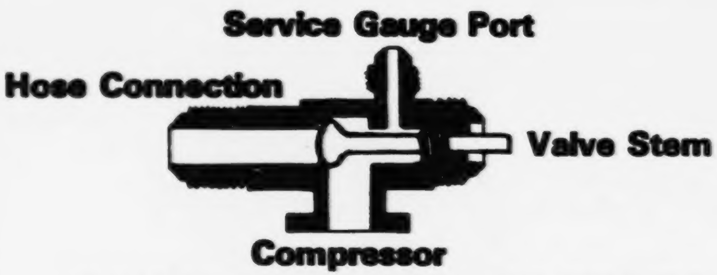


HIGH SIDE HAND VALVE OPEN,
LOW SIDE CLOSED

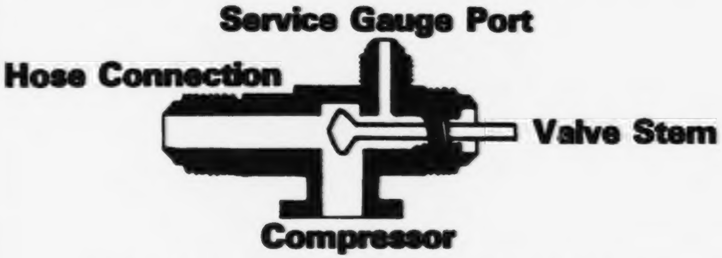


BOTH HAND VALVES OPEN

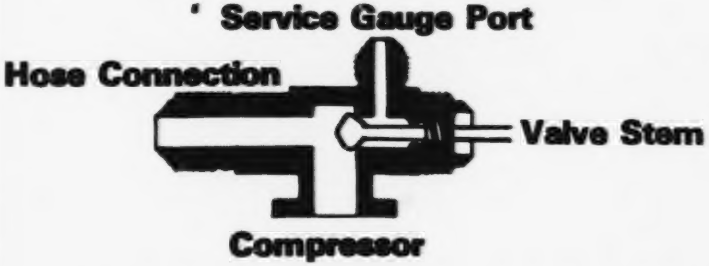
Service Valves


Service Gauge Port
Hose Connection
Valve Stem
Compressor

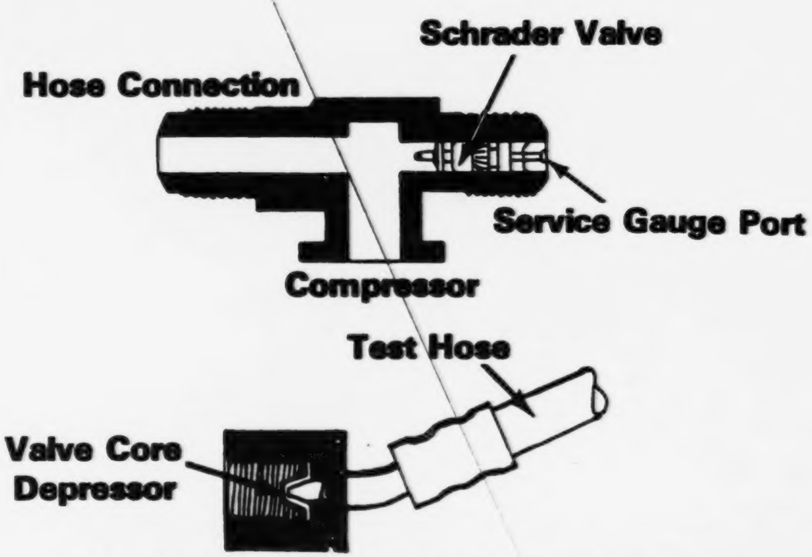
FRONT-SEATED SHUT-OFF POSITION


Service Gauge Port
Hose Connection
Valve Stem
Compressor

MIDPOSITION TEST POSITION


Service Gauge Port
Hose Connection
Valve Stem
Compressor

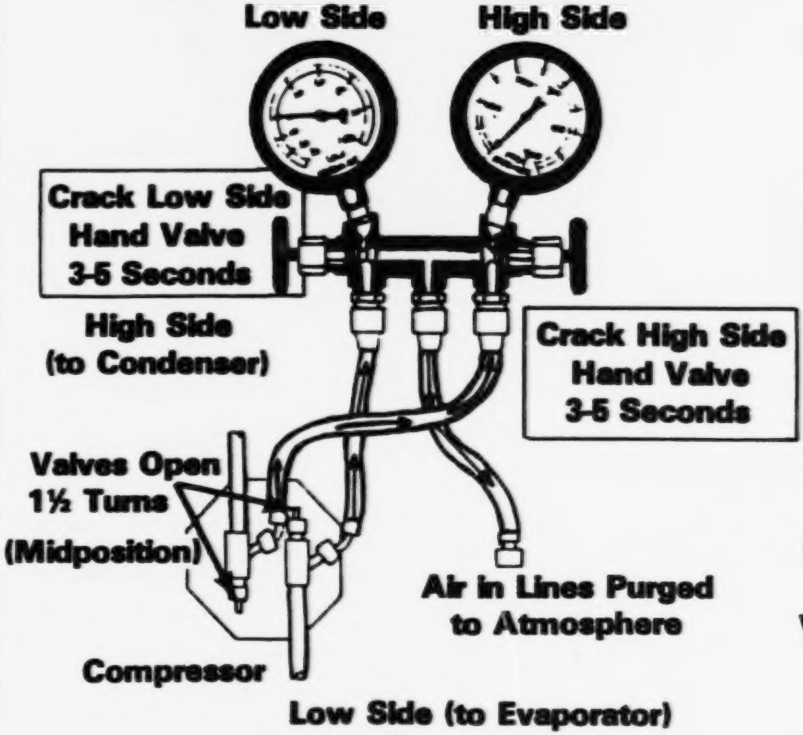
BACK-SEATED OPERATING POSITION


Schrader Valve
Hose Connection
Service Gauge Port
Compressor
Test Hose
Valve Core
Depressor

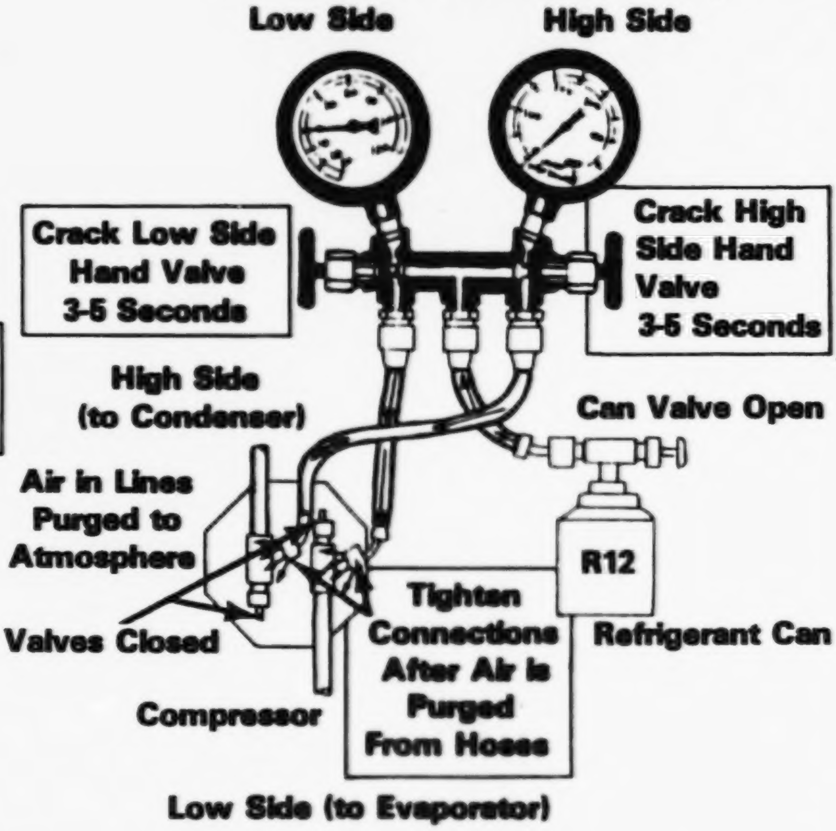
COMPRESSOR FITTING SCHRADER VALVE

Purging the Charging Hoses of Air

METHOD 1
(USING SYSTEM REFRIGERANT)

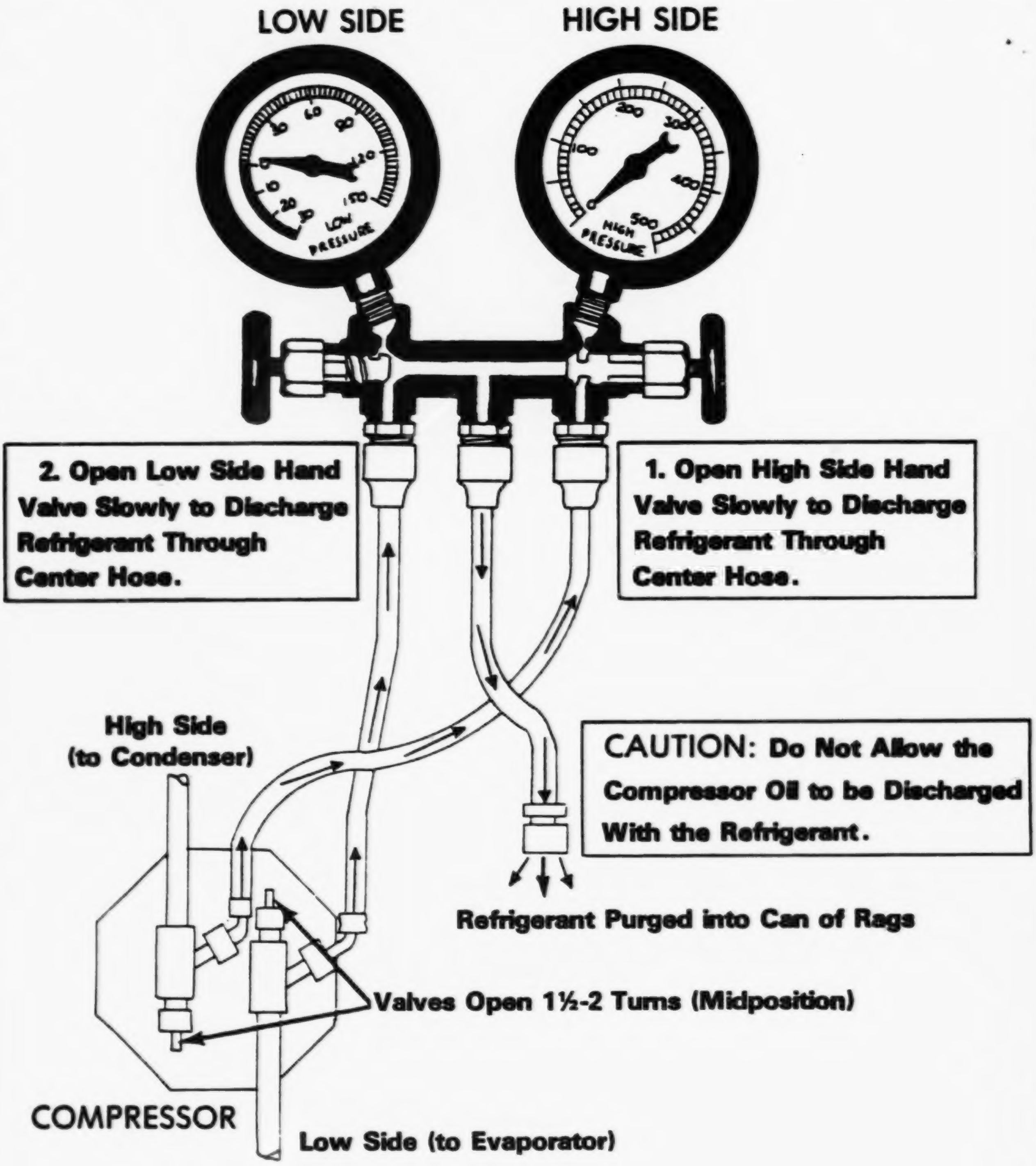

Low Side
High Side
Crack Low Side Hand Valve 3-5 Seconds
High Side (to Condenser)
Crack High Side Hand Valve 3-5 Seconds
Valves Open 1½ Turns (Midposition)
Air in Lines Purged to Atmosphere
Compressor
Low Side (to Evaporator)

METHOD 2
(USING REFRIGERANT CAN)


Low Side
High Side
Crack Low Side Hand Valve 3-5 Seconds
Crack High Side Hand Valve 3-5 Seconds
High Side (to Condenser)
Can Valve Open
Air in Lines Purged to Atmosphere
R12
Tighten Connections After Air is Purged From Hoses
Refrigerant Can
Valves Closed
Compressor
Low Side (to Evaporator)

NOTE: SYSTEM MUST NOT BE OPERATING WHEN PURGING TEST HOSES.

Discharging the System

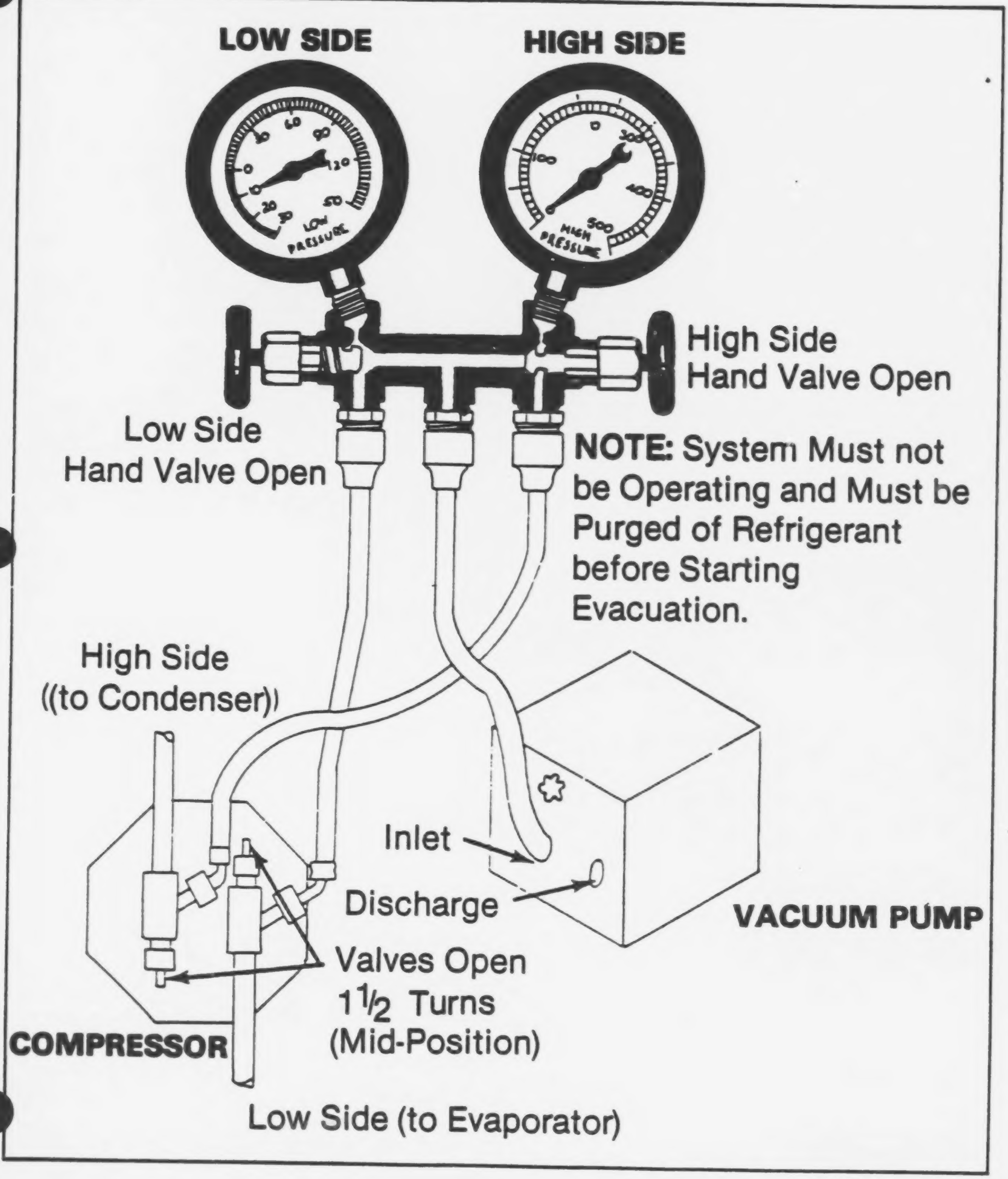

LOW SIDE
HIGH SIDE
LOW PRESSURE
HIGH PRESSURE
High Side (to Condenser)
Refrigerant Purged into Can of Rags
Valves Open 1½-2 Turns (Midposition)
COMPRESSOR
Low Side (to Evaporator)

1. Open High Side Hand Valve Slowly to Discharge Refrigerant Through Center Hose.

2. Open Low Side Hand Valve Slowly to Discharge Refrigerant Through Center Hose.

CAUTION: **Do Not Allow the Compressor Oil to be Discharged With the Refrigerant.**

Evacuating the System



LOW SIDE
HIGH SIDE
LOW PRESSURE
HIGH PRESSURE
High Side Hand Valve Open
Low Side Hand Valve Open
High Side ((to Condenser))
Inlet
Discharge
VACUUM PUMP
Valves Open 1½ Turns (Mid-Position)
COMPRESSOR
Low Side (to Evaporator)

NOTE: System Must not be Operating and Must be Purged of Refrigerant before Starting Evacuation.

UNIT III

JOB SHEET #1, LESSON TWO

TEST SYSTEM FOR LEAKS

Equipment:

Manifold gauge set
Service valve wrench
Safety glasses
Halide leak detector
Propane cylinder
Fender covers

(NOTE: Each of the four operations in this Job Sheet will receive a separate evaluation. At the end, the four evaluations will be averaged to provide the student's final evaluation.)

Operation #1: Preparing the system

Procedure:	**Evaluation:** 3	2	1	N
1. Connect manifold gauge set.				
2. Place high and low compressor service valves in cracked position and place both manifold hand valves in closed position.				
3. Start engine, turn on air conditioner to maximum cooling and check gauges.				
(NOTE: A minimum value of 50 psi must be present in order to leak test. If sufficient refrigerant is present in system, omit next step and proceed with Operation #3.)				
Average of Operation #1 evaluations				

Operation #2: Adding refrigerant for leak test pressure with engine turned off

Procedure:	**Evaluation:** 3	2	1	N
1. Open high and low side manifold hand valves to purge hoses of air; then close the valves.				
2. Attach the center manifold hose to the refrigerant can tap.				
3. Open the refrigerant container service valve.				

Procedure:	Evaluation: 3	2	1	N
4. Open the high side manifold hand valve to allow refrigerant to enter system until a pressure of 50 psi is reached on the low side gauge. Then, close the high side hand valve.	___	___	___	___
5. Close the refrigerant container service valve.	___	___	___	___
Average of Operation #2 evaluations	___	___	___	___

Operation #3: Preparing the leak detector

Procedure:	Evaluation: 3	2	1	N
1. Install leak detector on propane tank.	___	___	___	___
2. Open valve and light the gas. Adjust for a low flame - about 1/2-inch above reactor plate.	___	___	___	___
3. Allow flame to burn until copper reactor plate becomes cherry red in color.	___	___	___	___
4. Lower flame until it is about 1/4-inch above or even with reactor plate.	___	___	___	___
5. Check sensitivity of reactor plate by passing hose over recently emptied R-12 can	___	___	___	___
Average of Operation #3 evaluations	___	___	___	___

Operation #4: Leak testing air conditioning system
(Engine OFF, system OFF)

(NOTE: If any oil is found on air conditioning hoses or components, a leak should be suspected; refrigerant oil will escape wherever there is a leak.)

Procedure:	Evaluation: 3	2	1	N
1. Move the search hose under all of the joints and connections in the system. Check all seals and control devices.	___	___	___	___

(NOTE: Keep search hose on underside of components as R-12 is heavier than air and will sink.)

Procedure:	**Evaluation:** 3	2	1	N
2. Disconnect any vacuum hoses connected to the system. Check the vacuum hose ports for refrigerant vapor.	___	___	___	___
3. Move leak detector over air conditioning system components and note reaction. If leaks are present, repair system according to Job Sheet #5. If no leaks are present evacuate and charge system using Job Sheet #2.	___	___	___	___
Average of Operation #4 evaluations	___	___	___	___

EVALUATION:	3	2	1	N
Average for operation # 1	___	___	___	___
Average for operation # 2	___	___	___	___
Average for operation # 3	___	___	___	___
Average for operation # 4	___	___	___	___
Average of four operations*	___	___	___	___

(*This average is the evaluation for competency V4 "Test the system for leaks.")

UNIT III

JOB SHEET #2, LESSON TWO

EVACUATE AND CHARGE SYSTEM

Equipment:

Manifold gauge set
Service valve wrench
Fender covers
Safety glasses
Refrigerant
Can tap
Vacuum pump
Shop towels

(NOTE: Each of the four operations in this Job Sheet will receive a separate evaluation. At the end, the four evaluations will be averaged to provide the student's final evaluation.)

Operation #1: Discharging system

Procedure:

Evaluation:
3 2 1 N

1. Connect manifold hoses into system, with blue hose to low side and red hose to high side. ____ ____ ____ ____

2. Stabilize system by running engine at fast idle for 10-15 minutes with all controls on maximum cooling position. ____ ____ ____ ____

   (NOTE: This procedure may not be possible due to system malfunction.)

3. Slow engine to normal idle and shut off engine and place center manifold hose in a clean shop towel. ____ ____ ____ ____

4. Place compressor service valves in mid-position and slowly open manifold to escape through center hose. ____ ____ ____ ____

   (NOTE: Open hand valves only enough to bleed off refrigerant as rapid purging draws excessive oil from the system. By placing center hose in shop towel, refrigerant oil loss can be detected.)

5. Close hand valves when refrigerant ceases to bleed off. Both manifold gauges read zero when system is purged. ____ ____ ____ ____

Average of Operation #1 evaluations ____ ____ ____ ____

Operation #2: Evacuating system

Procedure:

Evaluation:
3 2 1 N

1. After performing Operation #1, place compressor service valves in mid-position and close both manifold hand valves. ___ ___ ___ ___

2. Connect the center manifold hose to the vacuum pump and start the vacuum pump. ___ ___ ___ ___

3. Open low side manifold hand valve and observe the compound gauge needle. ___ ___ ___ ___

   (NOTE: Needle should be pulled into a slight vacuum. After about five minutes, the compound gauge needle should show less than 20 inches Hg and the high side gauge needle should be slightly below zero.)

4. If the high side gauge needle does not drop below zero - unless restricted by a stop - system blockage is indicated. Discontinue evacuation and remove obstruction in system. ___ ___ ___ ___

5. Operate the pump for 15 minutes and observe the gauges. System should be at a vacuum of 24-26 inches Hg minimum if there is no leak. If system is not down to 24-26 inches, close the low side manifold hand valve and observe the compound gauge. ___ ___ ___ ___

6. If the compound gauge needle rises, indicating loss of vacuum, there is a leak which must be repaired before evacuation continues. Leak test the system and repair as required. ___ ___ ___ ___

7. If no leak is evident, continue with the pumpdown. High side manifold hand valve may be opened at this time. Pump for a minimum of 30 minutes, longer if time permits. ___ ___ ___ ___

   (NOTE: The reason for pumping as low a vacuum as possible is to cause any moisture in the system to boil away. As shown in the table below, the boiling temperatures of water decreases as the vacuum applied to the system increases. The greater the vacuum applied to the system, the greater the moisture removal will be.)

Temperature at which water will boil when placed under a vacuum.

System Vacuum, psi	Temperature, F.
27.99	100
28.89	80
29.40	60
29.71	40
29.82	20
29.88	0

Procedure:

Evaluation:
3 2 1 N

8. After pumpdown, close the high and low side manifold hand valves. Shut off the vacuum pump and disconnect the manifold hose from vacuum pump. Replace protective cap on vacuum pump port. ___ ___ ___ ___

9. Note the compound gauge reading; it should read about 29 inches Hg. ___ ___ ___ ___

   (NOTE: The compound gauge needle should not rise faster than 1 inch Hg in five minutes. If the system fails to meet this requirement a partial charge must be added and the system leak tested.)

10. If a leak is detected, repair as necessary. ___ ___ ___ ___

Average of Operation #2 evaluations: ___ ___ ___ ___

Operation #3: Purge system for charging with pound cans

Procedure:

Evaluation:
3 2 1 N

1. After evacuating the system place the manifold hand valves in the closed position. ___ ___ ___ ___

2. Install can tap on refrigerant container and secure locking devices. (Can tap valve stem should be in the out or counterclockwise position). ___ ___ ___ ___

3. Connect manifold center hose to can tap. ___ ___ ___ ___

4. Pierce the container by screwing can tap valve stem in a clockwise direction. ___ ___ ___ ___

5. Purge line of air by opening can tap valve. ___ ___ ___ ___

   (NOTE: Center hose is not charged with refrigerant. DO NOT crack the high or low side hand valves at this time.)

Procedure:

Evaluation:
3 2 1 N

6. Loosen the center hose at the manifold connection until a hissing sound can be heard. Allow gases to escape for a few seconds; then re-tighten hose connection. __ __ __ __

Average of Operation #3 evaluations __ __ __ __

(NOTE: System is now purged and under a vacuum. To charge, perform either operation #4A or operation #4B).

Operation #4A: Charge system with refrigerant
(system OFF, engine NOT running)

(NOTE: With this method the refrigerant is forced into the system through the high side in a liquid state. Since the compressor is not operating, the pressure in the refrigerant container can force the liquid refrigerant into the system. Liquid refrigerant should NEVER be installed into the low side as liquid refrigerant can damage the compressor.)

Procedure:

Evaluation:
3 2 1 N

1. Open the high side manifold hand valve, then observe the low side gauge pressure. If the gauge needle does not move from the vacuum range into the pressure range system, blockage is indicated. __ __ __ __

   (NOTE: If system is blocked, correct the condition, evacuate, and continue charging procedure.)

2. Invert container and allow liquid refrigerant to enter the system until can is empty. (Tap the refrigerant container on the bottom; the can is empty if it gives a hollow ring.) __ __ __ __

3. Repeat this procedure with additional cans of refrigerant as required __ __ __ __

   (NOTE: Refer to manufacturer's specifications for the system capacity. If system cannot be fully charged using this method, the remaining refrigerant may be installed using Operation #4B.)

4. Close high side manifold hand valve and rotate the compressor clutch by hand several revolutions to insure that no liquid refrigerant entered low side of compressor. __ __ __ __

1018

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
5. Start the engine and set to fast idle, then engage the system to start the compressor. Set all controls for maximum cooling.	___	___	___	___
6. Conduct a performance test, then slow engine to idle and stop engine.	___	___	___	___
7. Back-seat compressor service valves and remove manifold hoses, then install protective caps on service valves.	___	___	___	___
Average of Operation #4A evaluations	___	___	___	___

Operation #4B: Charging system with refrigerant (system operating, engine running)

(NOTE: With this method the refrigerant must be installed through the low side.)

(CAUTION: *With the refrigerant can inverted, liquid refrigerant is forced into the charging hoses. DO NOT invert the refrigerant container if low side pressure is OVER 40 psi. Regulating the can tap valve or the low side manifold hand valve will insure a low side pressure of 40 psi or BELOW. Liquid refrigerant entering the compressor low side can cause serious damage to compressor internal parts.)*

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
1. Insure that both manifold hand valves are closed and place compressor service valves in mid-position.	___	___	___	___
2. Start engine and adjust speed to about 1,250 rpm, then adjust air conditioner controls for maximum cooling, blower on high speed.	___	___	___	___
3. Open low side gauge manifold hand valve to allow gaseous refrigerant to enter system.	___	___	___	___
4. After the low side gauge pressure drops below 40 psi the can should be inverted to allow more rapid charging of refrigerant until can is empty. (Tap bottom of can, empty can will make hollow ring.)	___	___	___	___

Procedure:

Evaluation:
3 2 1 N

5. Repeat this procedure with additional cans of refrigerant until system is charged. Refer to manufacturer's specifications for the system capacity. ___ ___ ___ ___

   (NOTE: If the system capacity is not known, charge the unit until the sight glass is clear; then add another 1/4-pound of refrigerant.)

6. Close the low side manifold hand valve and remove can tap from the center hose. ___ ___ ___ ___

7. Conduct a performance test. ___ ___ ___ ___

8. Back seat the compressor service valves and remove the manifold and gauge set. Install protective caps on service valve ports. ___ ___ ___ ___

Average of Operation #4B evaluations ___ ___ ___ ___

EVALUATIONS:	**3**	**2**	**1**	**N**
Average for Operation # 1				
Average for Operation # 2				
Average for Operation # 3				
Average for Operation # 4A or 4B				
Average of four operations*:				

(*This average is the evaluation for competency V6 "Evacuate and charge system using vacuum pump or charging system.")

UNIT III

JOB SHEET #3, LESSON TWO

REMOVE AND REPLACE A CONDENSER

Equipment:

Fender covers
Safety glasses
Flexible hose and funnel
Hand tools
Line wrench
Flare-nut wrenches
Refrigerant oil
Manifold gauge
Vehicle service manual
Replacement condenser

(NOTE: Always consult the vehicle service manual for specific procedures)

Procedure:

	Evaluation: 3	2	1	N
1. Discharge system by performing Job Sheet #2, Operation #1.	___	___	___	___
2. Remove fan shield and/or radiator, if necessary, to gain access to condenser.	___	___	___	___
3. Disconnect inlet and outlet lines from condenser. Cap or plug ends of lines to keep out air, moisture and dirt.	___	___	___	___
4. Remove condenser mounting screws and remove condenser.	___	___	___	___
5. Add one ounce of new refrigerant oil to replacement condenser and position replacement condenser	___	___	___	___
6. Install condenser mounting screws.	___	___	___	___
7. Install outlet lines to condenser, first lubricating them.	___	___	___	___
8. Reinstall fan shield, radiator, or any other parts removed to gain access.	___	___	___	___
9. Evacuate and charge system by performing Job Sheet #2, Operations 2-4.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency V3: "Remove and reinstall condenser.")

UNIT III

JOB SHEET #4, LESSON TWO

REMOVE AND REINSTALL COMPRESSOR

Equipment:

Manifold gauge set
Service valve wrench
Fender covers
Safety glasses
Refrigerant
Can tap
Vacuum pump
Shop towels
Sockets and wrenches

Procedure:		**Evaluation:**			
		3	**2**	**1**	**N**
1.	Discharge system by performing Job Sheet #2, Operation #1.	___	___	___	___
2.	Disconnect hoses from compressor, using extreme caution regardless of gauge readings from step 1, and plug hoses.	___	___	___	___
3.	Remove compressor from mounting bracket.	___	___	___	___
4.	Unscrew the oil test fitting and pour the oil into a clean glass container. Examine oil for dirt, water or other impurities. If any are present, discard the compressor and the desiccant bag in the VIR unit. Flush the other system components with liquid refrigerant.	___	___	___	___
5.	If the compressor oil is clean and free of any impurities, discard the oil and put fresh oil into the compressor.	___	___	___	___
	(Note: If system components have been flushed, replace the full charge of oil. If not, add no more new oil than you poured out).				
6.	Install compressor in mounting bracket.	___	___	___	___
7.	Reconnect all hoses to compressor.	___	___	___	___
8.	Put a small amount of refrigerant in system and test for leaks by performing Job Sheet #1.	___	___	___	___

Procedure:	Evaluation: 3	2	1	N
9. If system passes leak test, evacuate and charge system by performing Job Sheet #2, Operations 2-4.	___	___	___	___
10. Retest system for leaks.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for competency V3 "Remove and reinstall compressor.")

UNIT III

JOB SHEET # 5, LESSON TWO

REPAIR LEAKS IN AIR CONDITIONING SYSTEM AND CHECK AND SERVICE AIR CONDITIONING HOSES

Equipment:

Manifold gauge set
Service valve wrench
Safety glasses
Halide leak detector
Propane cylinder
Fender covers
Hand tools

Procedure:

	Evaluation: 3	2	1	N
1. Check system for leaks by performing Job Sheet #1.	___	___	___	___
2. If leaks are discovered in system, including hoses, discharge system by performing Job Sheet #2, Operation #1.	___	___	___	___
3. If condenser is damaged, perform Job Sheet #4.	___	___	___	___
4. If hoses or hose connections are damaged in any way, replace them.	___	___	___	___
5. Inspect VIR unit for cracks or other damage. If it appears to be intact, clean it with a suitable cleaner. Dry it thoroughly and replace the desiccant bag.	___	___	___	___
6. If the evaporator shows any sign of damage, replace it.	___	___	___	___
7. Check the control system, connecting wires, vacuum hoses, and vacuum motors for damage. Install new parts as necessary.	___	___	___	___
8. Check the clutch pulley for proper operation.	___	___	___	___
9. Check the compressor for damage.	___	___	___	___
10. If leaks were discovered and system was discharged, reinstall connections and put a small amount of refrigerant in system.	___	___	___	___

Procedure:

Evaluation:
3 2 1 N

11. Check system for leaks by performing Job Sheet #1. ___ ___ ___ ___

12. If system shows no leaks, evacuate and charge system by performing Job Sheet #2. ___ ___ ___ ___

13. Retest system for leaks by performing Job Sheet #1. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the evaluation for competencies V5 "Repair leaks in air conditioning system" and V7 "Check and service air conditioning hoses.")

(NOTE: Due to the high pressure of air conditioning systems it is almost always necessary to replace any components with leaks).

MODULE: MECHANICAL SERVICES

UNIT III: AIR CONDITIONING SYSTEMS

UNIT TEST

I. Match the terms in the left column with the most closely associated definition in the right column.

_____1. Special moisture-free type

_____2. Agent used to absorb moisture

_____3. Removing heat by evaporation

_____4. Adding refrigerant

_____5. Liquid changes to gas

_____6. Removing refrigerant

_____7. Any agent which removes heat

_____8. Removing air and moisture

_____9. Boils at -21.6 degrees F.

A. Evacuate

B. Refrigeration

C. Desiccant

D. Charge

E. Boiling point

AB. R-12

AC. Refrigerant oil

AD. Compressor

AE. Receiver

BC. Refrigerant

BD. Discharge

II. Match the parts of the diagram below, showing the basic air conditioning components with the correct label.

_____10. Compressor

_____11. Low pressure

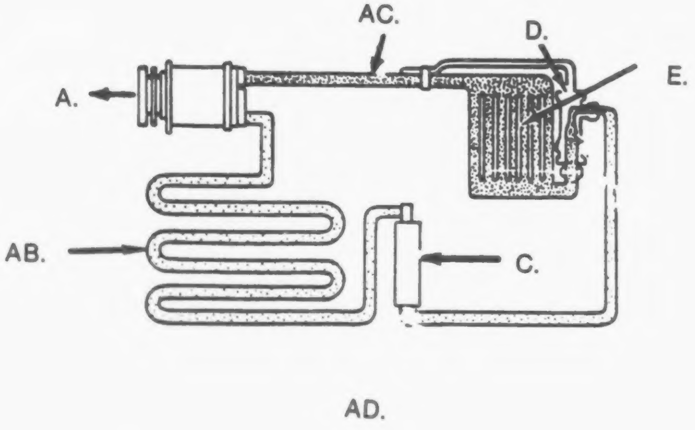
_____12. Expansion valve

_____13. Evaporator

_____14. Condenser

_____15. Receiver-drier

_____16. High pressure



III. Match the parts of the diagram below, showing the manifold gauge, with the correct labels.

_____17. Low-side gauge

_____18. Pressure (PSI)

_____19. High-side gauge

_____20. Vacuum

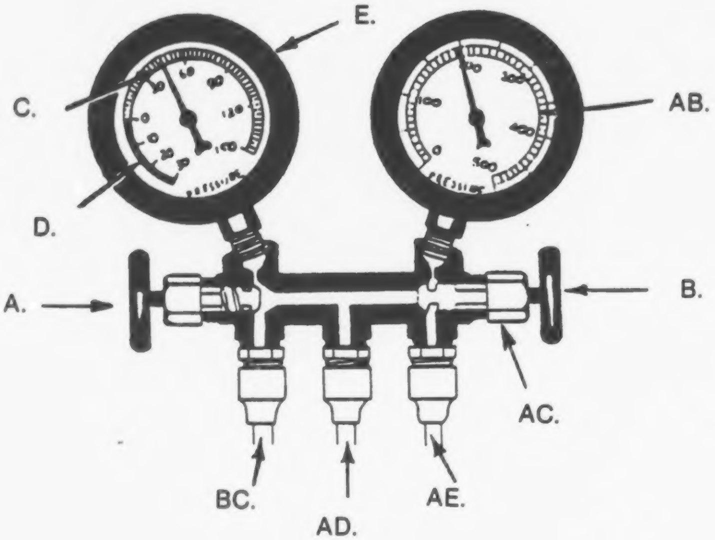
_____21. Low-side hand valve

_____22. High-side hand valve

_____23. Low-side service port

_____24. Charge/purge hose

_____25. High-side service port



IV. Select the best answer from the choices listed in the questions below.

_____26. The "high side" of an air conditioning system refers to the: (a) side with the high pressure, (b) side coming into the top of the compressor, (c) side with the blue service port, (d) side with the evaporator, (e) side with the suction.

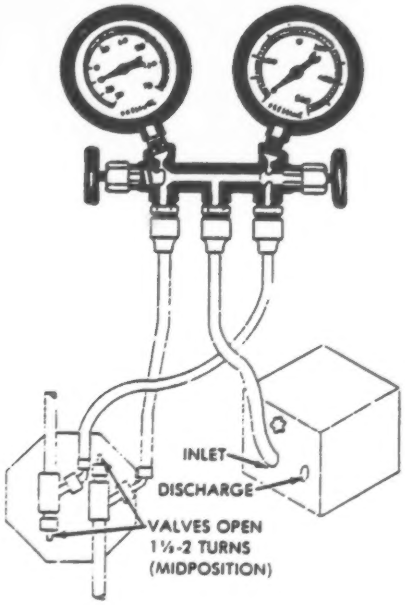
_____27. The "low side" of an air conditioning system refers to the: (a) side with the high pressure, (b) side coming into the bottom of the compressor, (c) side with the red service port, (d) side with the condenser, (e) side with the suction.

_____28. In the General Motors Cycling Clutch Orifice Tube system the expansion tube replaces the: (a) expansion valve, (b) capillary tube, (c) condenser, (d) POA valve, (e) receiver-drier.

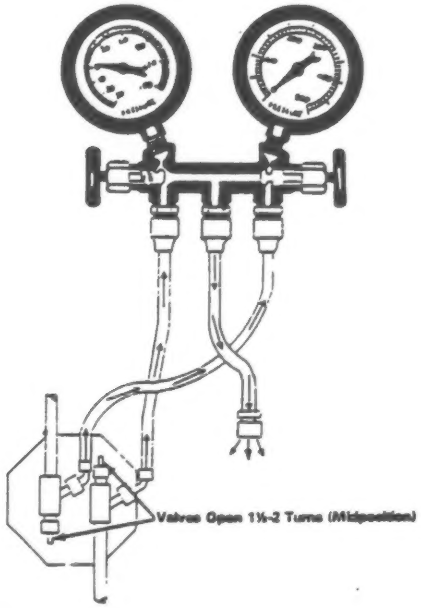
_____29. In the General Motors Cycling Clutch Orifice Tube system the m accumulator replaces the: (a) expansion valve, (b) capillary tube, (c) condenser, (d) POA valve, (e) receiver-drier.

_____30. In the General Motors Cycling Clutch Orifice Tube system the thermostat replaces the: (a) expansion valve, (b) capillary tube, (c) condenser, (d) POA valve, (e) receiver-drier.

_____31. The illustration below shows an air conditioning system being (a) evaporated (b) discharged, (c) evacuated, (d) charged, (e) sealed.


INLET
DISCHARGE
VALVES OPEN
1½-2 TURNS
(MIDPOSITION)

_____32. The illustration below shows an air conditioning system being (a) evaporated (b) discharged, (c) evacuated, (d) charged, (e) sealed.


Valves Open 1½-2 Turns (Midposition)

(NOTE: Completion of this test is the evaluation for Competency V1 "Identify Air Conditioning Components and Service." Of the 32 questions, a score of _____ = 3, _____ = 2, _____ = 1, _____ or below, students should retake this portion of the test.)

ANSWERS TO UNIT III TEST

1. AC
2. C
3. B
4. D
5. E
6. BD
7. BC
8. A
9. AB

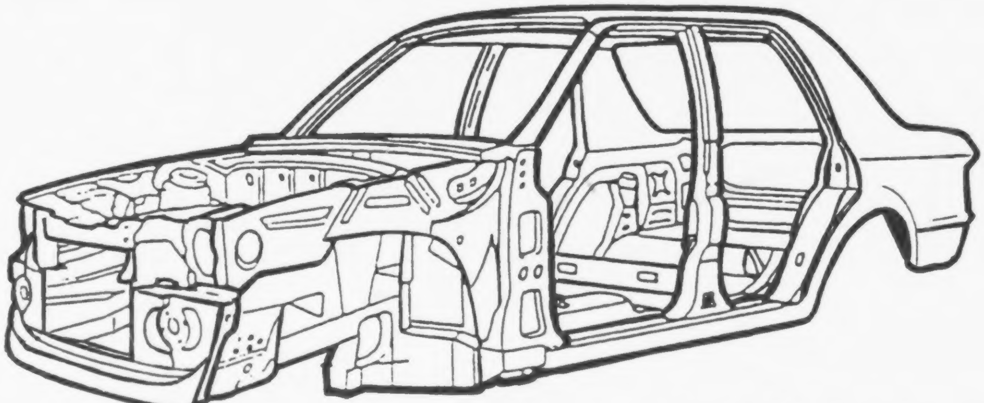
10. A
11. AC
12. D
13. E
14. AB
15. C
16. AD

17. E
18. C
19. AB
20. D
21. A
22. B
23. BC
24. AD
25. AE

26. A
27. E
28. A
29. E
30. D
31. C
32. B
33. C
34. D
35. A
36. B

Auto Body Repair Curriculum Guide

INSTRUCTOR'S GUIDE



MODULE 7:

- Steering and Suspension Systems
- Conventional Construction
- Unibody Construction
- Damage Analysis
- Unibody Repair
- Stress Relief
- Sectioning

Frame-body and Unibody Construction and Repair

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AUTO BODY CURRICULUM
Instructor's guide

MODULE 7:
FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

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Auto Body

Frame-body and Unibody Construction and Repair

Cross-Reference Table of Instructional Materials

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MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT I: SUSPENSION SYSTEMS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify suspension systems, front and rear, and be able to remove and replace front and rear suspension systems. Mastery will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Match terms with their definitions or illustrations (Competency W1, Part I, Unit I test)

II. Identify front suspension systems (Competency W1, Part I, Unit I test)

III. Identify functions of parts of front suspension systems (Competency W1, Part I, Unit I test)

IV. Identify principles of servicing suspension systems (Competency W1, Part I, Unit I test)

V. Demonstrate the ability to:

   a. Remove and re-install SLA front suspension systems (Competencies W3 and W6, Job Sheet #1)

   b. Remove and reinstall MacPherson strut suspension system (Competencies W3 and W6, Job Sheet #2)

   c. Service brake system (Competency W11, Job Sheets #1 and #2)

Lesson 2:

I. Identify terms associated with rear suspension systems (Competency W2, Part II, Unit I test)

II. Identify principles of rear suspensions (Competency W2, Part II, Unit I test)

III. Identify parts and functions of rear suspension systems (Competency W2, Part II, Unit I test)

IV. Demonstrate the ability to remove and re-install rear suspension systems (Competency W4, Job Sheet #1)

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT I: SUSPENSION SYSTEMS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

    1. Lesson 1: Identifying Front Suspension Systems

        a. Information outline

        b. Job sheets

            JS # 1: Remove and replace SLA suspension system
            JS # 2: Remove and replace MacPherson-strut suspension system

        c. Transparency masters

            TM#1: SLA suspension system
            TM#2: Modified MacPherson-strut suspension system
            TM#3: True MacPherson-strut suspension system

    2. Lesson 2: Identifying Rear Suspension Systems

        a. Information outline

        b. Job sheet

            JS#1: Remove and replace rear suspension system

        c. Transparency masters

            TM#1: Solid-axle coil spring
            TM#2: Solid-axle leaf spring
            TM#3: True MacPherson-strut
            TM#4: Modified MacPherson-strut
            TM#5: Flex drive axle
            TM#6: Torsion beam suspension

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. The job sheets for removing and replacing front suspension systems can also serve as the evaluation for Competency W6 "Service suspension system." If only part of the suspension system is replaced, then only W6 would be fulfilled.

B. Supplemental information will have to be provided for Competency W11 "Service brake system." It was given a low priority. The instructor will have to determine the exact procedure for evaluation.

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MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT I: SUSPENSION SYSTEMS

LESSON 1: IDENTIFYING FRONT SUSPENSION SYSTEMS

I. **Terms and definitions**

A. Air suspension – Any suspension system using air, contained within a butyl air bag, as a spring in a vehicle suspension system.

B. Axle – An actual or theoretical crossbar supporting a vehicle and upon which one or more wheels turn.

C. Ball-joint – A flexible joint consisting of a ball within a socket. It is used in most front suspension systems.

D. Ball-joint suspension – A type of front suspension system in which the knuckle assembly is attached directly to the upper and lower arms of the suspension with ball-joints.

E. Brake reactor rod -- A part of some suspension systems connecting the lower control arm to the vehicle frame or front rail in order to maintain the lateral position of the lower ball joint. Also known as a brake reaction rod and sometimes referred to as a strut.

F. Coil Spring – A spring made of metal, formed by shaping the metal into a thick wire and winding it into a coil.

G. Control arm -- The connecting link between the car and the wheels in most suspension systems. Each end of the control arm pivots, allowing vertical movement of the wheels.

H. Independent front suspension – Any front-suspension system in which each front wheel moves independently of the other for jounce and rebound.

I. Independent rear suspension – Rear suspension systems that allow each wheel to move independently of the other for jounce and rebound.

J. Jounce – The motion caused by a wheel going over a bump and compressing the spring, with the wheel moving closer to the vehicle body.

K. Rebound – The motion caused by a wheel going into a dip or returning from a jounce, thus extending the spring, with the wheel moving away from the vehicle.

L. Shock Absorber – A damping device placed at each vehicle wheel in most suspension systems to control jounce and rebound.

M. Short-arm, long-arm suspension (SLA) -- The conventional front suspension system which uses a short upper control arm and a longer lower control arm. SLA is also known as parallel-arm suspension and ball-joint suspension.

N. Spindle – The axle shaft on which the wheels rotate. The wheel bearings ride on the spindle.

O. Spring -- Any device which changes shape under pressure and returns to its original shape when pressure is stopped.

P. Spring rate -- The load required to move a spring or a suspended wheel a given distance. The spring rate indicates the firmness of a given spring or suspension system.

Q. Sway bar -- A shaft connected between two lower control arms to help control body roll on turns. Also known as a stabilizer bar.

R. Suspension system -- Any configuration of components which supports the weight of a vehicle on its axles and wheels.

S. Wheelbase -- The distance between the front and rear axles. It is measured from the exact center of each axle.

II. **Suspension systems**

A. There are three functions of any suspension system.

1. Supporting the weight of the vehicle so that all four wheels are in proper contact with the road surface

2. Damping (cushioning road shocks)

3. Position the wheels properly in relation to the vehicle in both straight-ahead driving and turning

B. Suspension systems differ from vehicle-type to vehicle-type. The front and rear suspensions also differ.

1. In addition to the three functions of all suspension systems, front suspensions must allow for vehicle steering

2. The factors influencing suspension design

a. Load-carrying requirements of the vehicle

b. Whether vehicle is frame-body or unibody

c. Location of engine and of drive axle

C. Front suspension systems

(NOTE: The following two front suspension systems are the most common systems employed in modern vehicle construction. There are many variations and vehicle specifications should always be consulted for each vehicle).

1. SLA (Short-arm, long-arm suspension)

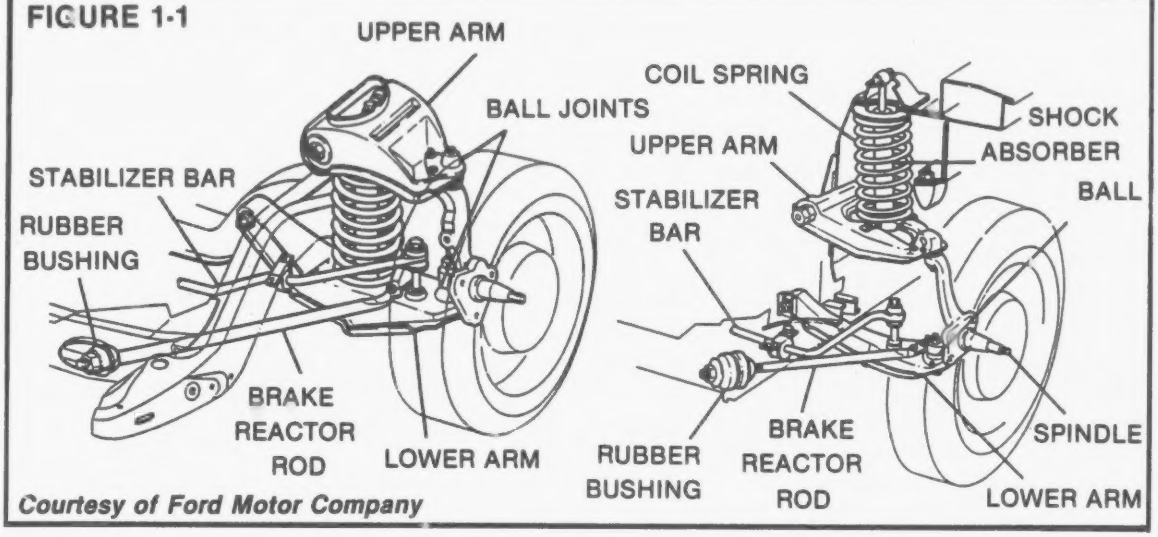
a. SLA system is generally associated with frame-body construction.

b. SLA system is generally associated with rear-wheel-drive construction.

c. SLA system is mounted to vehicle by attaching upper and lower control arms to vehicle frame. The lower control arm may be attached at one point or two points. Those attached at only one point use a brake reactor rod.

d. The most common type of SLA system has the spring on the lower control arm, but many systems have the spring on the upper control arm (FIG. 1-1)

FIGURE 1-1


UPPER ARM
BALL JOINTS
STABILIZER BAR
RUBBER BUSHING
BRAKE REACTOR ROD
LOWER ARM
COIL SPRING
UPPER ARM
SHOCK ABSORBER
BALL
STABILIZER BAR
RUBBER BUSHING
BRAKE REACTOR ROD
SPINDLE
LOWER ARM

Courtesy of Ford Motor Company

(NOTE: The suspensions above show a lower control arm attached at only one point and a brake reactor rod.)

2. MacPherson-strut suspension

a. Strut system is basic design of present unibody construction.

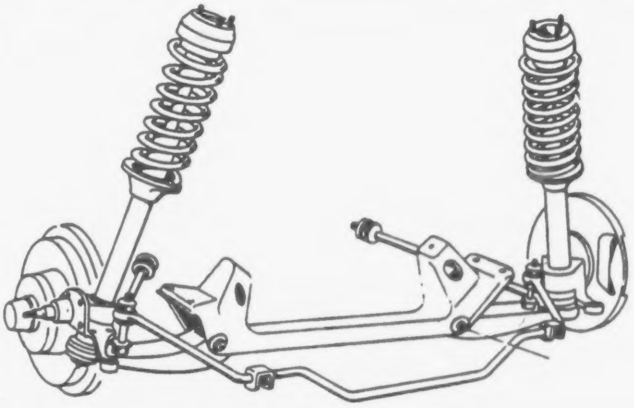
b. Strut system is generally associated with front-wheel drive.

c. Strut system was invented in 1940s, but did not become popular until transverse-mounted front engine design became popular. Strut system takes up less room than SLA, allowing more room for front drive trains. Strut also has less parts, thus less weight.

d. Strut system is mounted to vehicle by having strut tower panel built into vehicle for attaching top of strut. Lower control arm attaches to body structural metal (usually the front frame rail) or to a crossmember or cradle assembly. (FIG. 1-2)

(NOTE: The illustration below shows a lower attachment to a crossmember.)

FIGURE 1-2

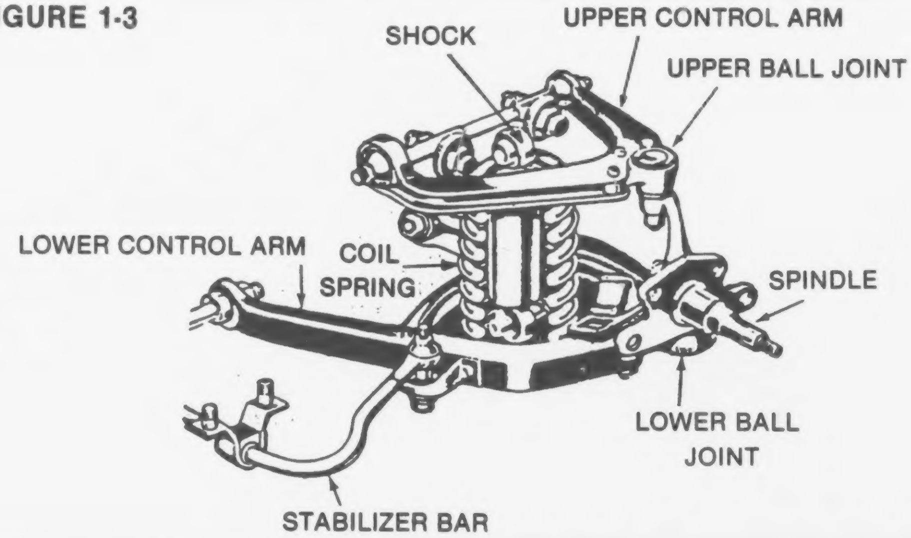


Courtesy of Chart Industries, Ltd.

III. **Function of parts of front suspension systems**

A. Conventional short-arm, long-arm (SLA) front suspension (FIG. 1-3)

FIGURE 1-3


SHOCK
UPPER CONTROL ARM
UPPER BALL JOINT
LOWER CONTROL ARM
COIL SPRING
SPINDLE
LOWER BALL JOINT
STABILIZER BAR

1. Upper and lower control arms
   a. Provide connecting link between steering knuckle and vehicle body or frame
   b. Allow vertical movement of suspension

   c. Position the wheels

      (NOTE: Because of the shape of the type of upper and lower control arms, which are attached at two points, they are sometimes known as "A-arms" or "A-frames.")

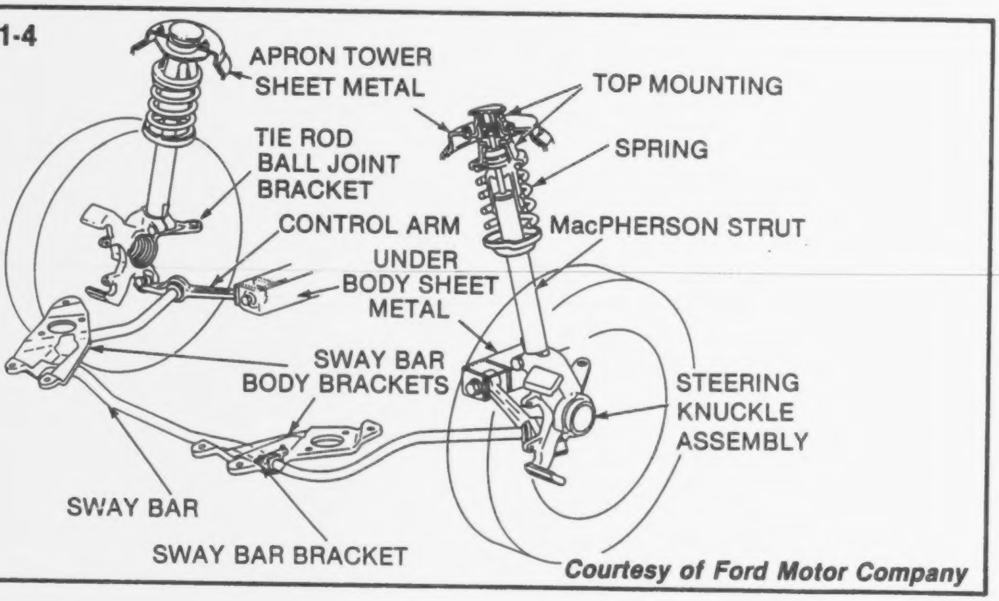
2. Upper and lower ball joints
   a. Connect steering knuckle to control arms
   b. Allow multi-directional movement of steering knuckle, including turning movements
3. Steering knuckle/spindle assembly
   a. Connects wheel to control-arm assemblies
   b. Allows tire to rotate as well as turn for steering purposes
4. Coil spring
   a. Usually located between lower control arm and frame
   b. Allows for jounce and rebound
   c. Supports weight of the vehicle and controls vehicle height
5. Shock absorber
   a. Usually located inside coil spring; attached to same components as spring
   b. Provides damping of jounce and rebound

      (Note: Shock absorbers provide control of jounce and rebound. They allow enough give to let the spring provide for jounce and rebound, but provide enough resistance to return the spring to normal state after jounce or rebound.)

6. Sway bar
   a. Attached between lower control arms
   b. Helps control tipping of the vehicle body on turns

B. MacPherson-strut suspension. (FIG. 1-4)

FIGURE 1-4


APRON TOWER
SHEET METAL
TOP MOUNTING
SPRING
TIE ROD
BALL JOINT
BRACKET
CONTROL ARM
MacPHERSON STRUT
UNDER
BODY SHEET
METAL
SWAY BAR
BODY BRACKETS
STEERING
KNUCKLE
ASSEMBLY
SWAY BAR
SWAY BAR BRACKET

Courtesy of Ford Motor Company

1. Control arm
   a. Attaches strut assembly to crossmember or directly to unibody
   b. Allows vertical movement of suspension
2. Ball joint
   a. Connects MacPherson strut to control arm
   b. Allows multi-directional movement of MacPherson strut, including turning movements
3. Steering knuckle/spindle
   a. Connects wheel to control arm assembly and strut
   b. Allows tire to rotate as well as turn
4. Coil spring
   a. Located on upper portion of MacPherson strut

      (NOTE: Some struts are "modified" struts, usually meaning the coil spring is located between the lower control arm and either crossmember or the unibody).

   b. Allows for jounce and rebound

   c. Supports weight of the vehicle

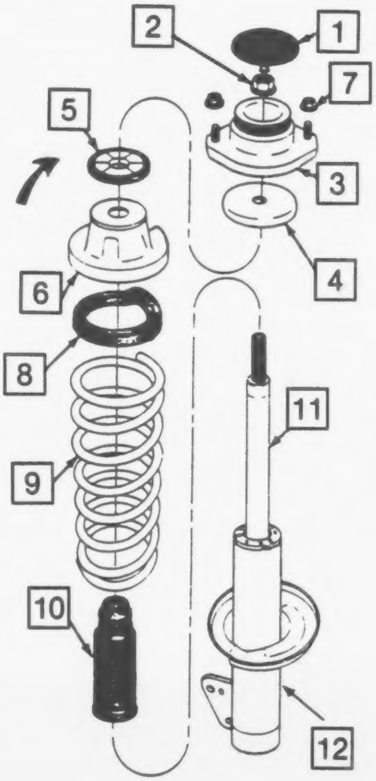
5. MacPherson-strut
   a. Located between strut tower (apron tower) and control arm
   b. Provides damping of jounce and rebound
   c. Sets steering axis inclination (see Unit III) and supports steering knuckle in vertical position

6. Sway bar
   a. Attached between lower control arms
   b. Helps control tipping of the vehicle body on turns
   c. In some designs, also controls lateral movement of lower control arms

C. Parts of strut in MacPherson-strut system (FIG. 1-5)

FIGURE 1-5

1. DUST CAP
2. NUT AND WASHER
3. UPPER MOUNT
4. THRUST PLATE
5. BEARING AND SEAL
6. SPRING SEAT
7. NUT
8. SPRING INSULATOR
9. SPRING
10. FRONT JOUNCE BUMPER
11. SHOCK ABSORBER SHAFT
12. STRUT TUBE



Courtesy of Ford Motor Company

IV. Servicing suspension and brake systems.

A. Because it is often the body shop technician who corrects suspension problems in MacPherson-strut vehicles, the body shop technician must also have some knowledge of servicing suspension and brake systems.

B. Lubrication and servicing suspension systems

1. Most MacPherson strut-type systems have little in the way of lubrication requirements. Vehicle specifications should be checked. In most cases, suspension lubrication is easily accomplished.

2. Replacing of damaged suspension components, in cases where body damage is not a factor, is easily accomplished once removal and replacement procedures from Job Sheet #2 are mastered.

(NOTE: When replacing suspension components, check lubrication recommendations).

C. Servicing brake systems

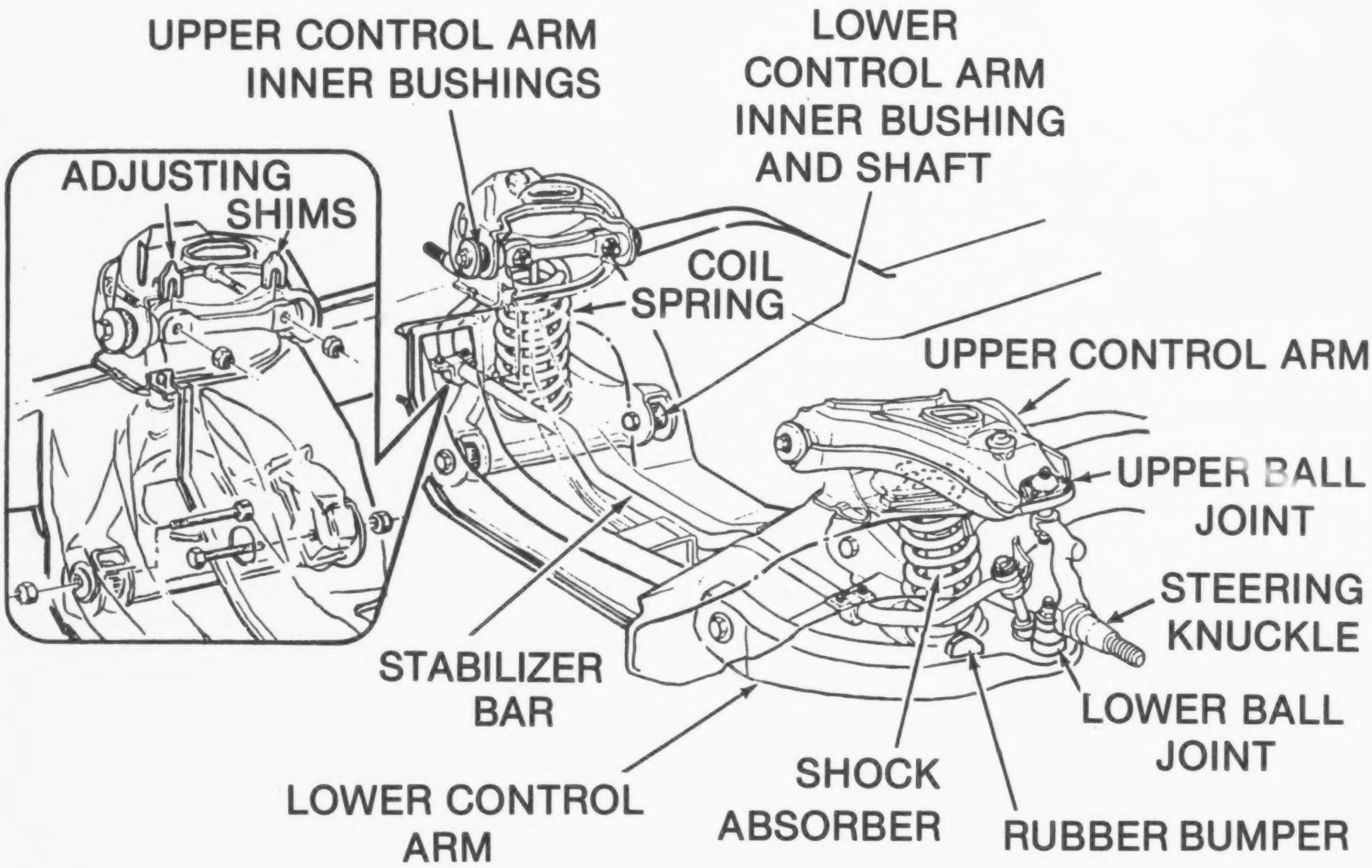
1. Often it is necessary to service brake systems after the replacement of MacPherson struts. It is sometimes possible to avoid any servicing of brake systems by leaving brake calipers and brake lines tied to the vehicle during repairs.

2. If disc brake components are damaged as a result of a collision, they are always replaced. Consult manufacturer's specifications for replacement.

3. If it is necessary to replace a master cylinder, consult vehicle specifications for replacement.

4. If it is necessary to bleed brake lines, perform procedure according to vehicle specifications.

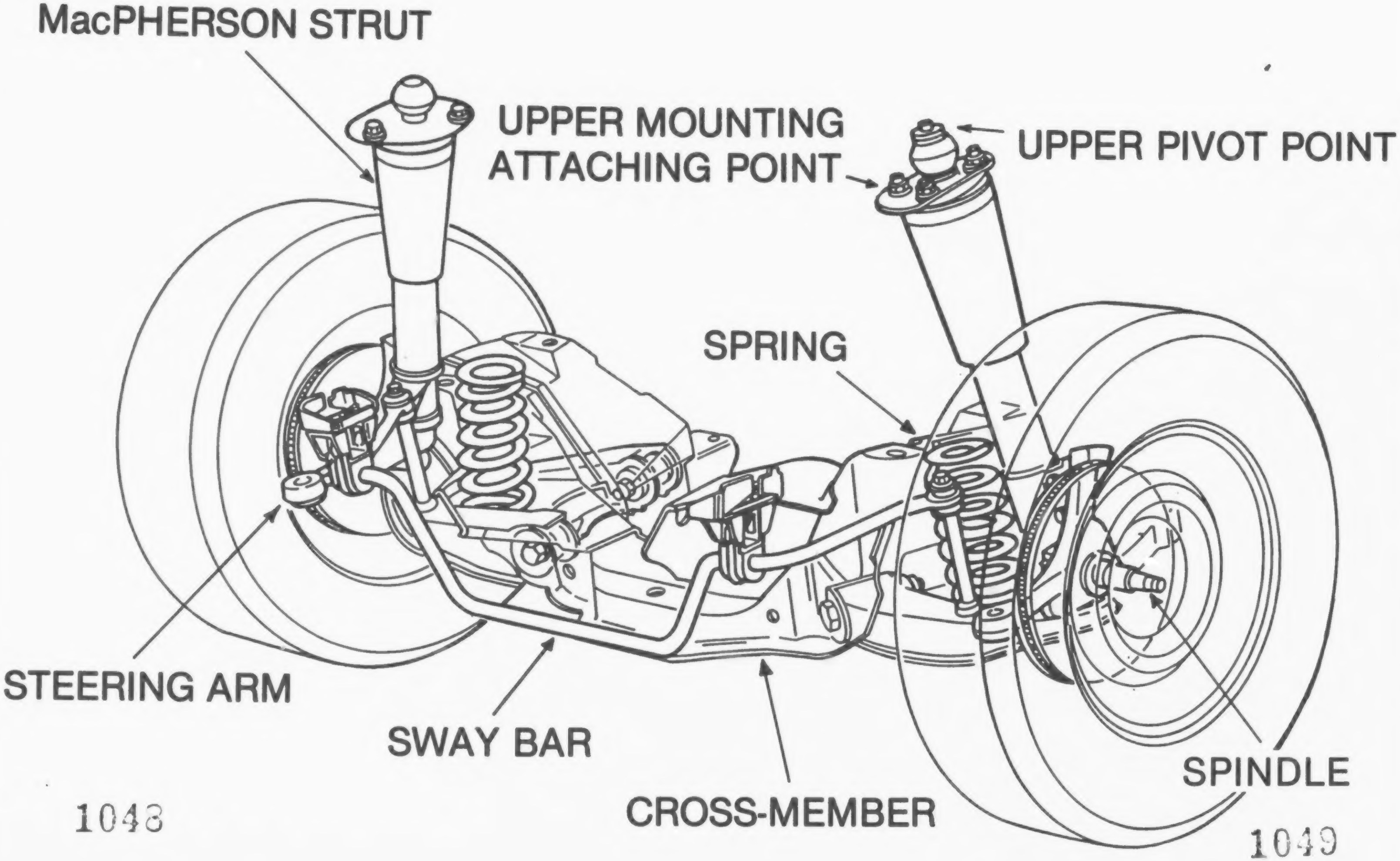
SLA Front Suspension


UPPER CONTROL ARM INNER BUSHINGS
LOWER CONTROL ARM INNER BUSHING AND SHAFT
ADJUSTING SHIMS
COIL SPRING
UPPER CONTROL ARM
UPPER BALL JOINT
STEERING KNUCKLE
LOWER BALL JOINT
STABILIZER BAR
LOWER CONTROL ARM
SHOCK ABSORBER
RUBBER BUMPER

1046

1047

Modified MacPherson Strut Front Suspension


MacPHERSON STRUT
UPPER MOUNTING ATTACHING POINT
UPPER PIVOT POINT
SPRING
STEERING ARM
SWAY BAR
CROSS-MEMBER
SPINDLE

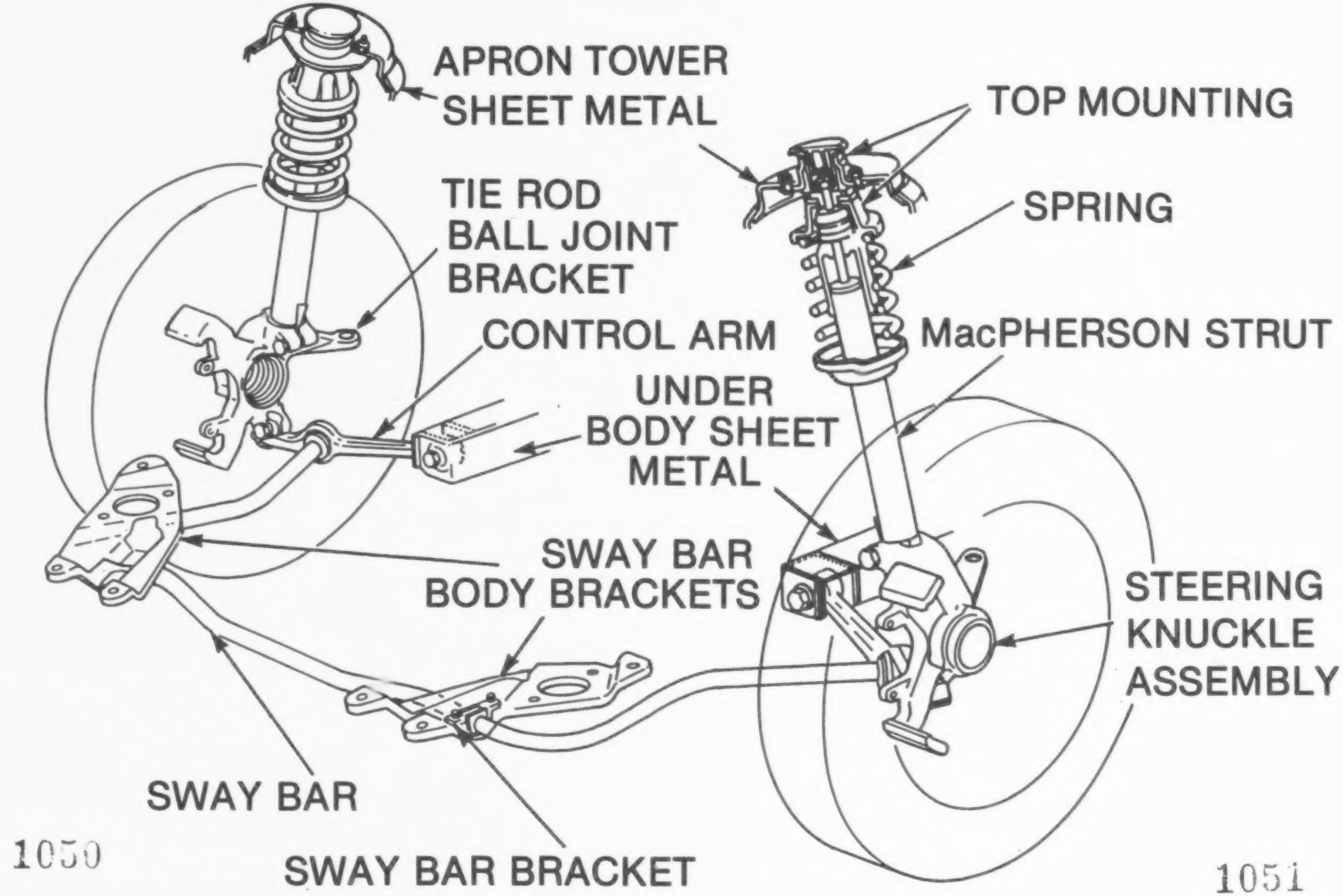
1048

1049

Courtesy of Ford Motor Company

TM 2

True MacPherson Strut Front Suspension


APRON TOWER SHEET METAL
TOP MOUNTING
TIE ROD BALL JOINT BRACKET
SPRING
CONTROL ARM
MacPHERSON STRUT
UNDER BODY SHEET METAL
SWAY BAR BODY BRACKETS
STEERING KNUCKLE ASSEMBLY
SWAY BAR
SWAY BAR BRACKET

1050

1051

Courtesy of Ford Motor Company

UNIT I

JOB SHEET # 1, LESSON ONE

REMOVE AND REPLACE SLA SUSPENSION SYSTEM

(NOTE: Manufacturer's recommendations must always be followed when removing SLA suspension systems)

Equipment

Vehicle with SLA suspension
Floor jack
Jack stands
Common hand tools, including hammer, rachets, sockets and diagonal cutting pliers
Spring compressor tool
Suitable tool to remove ball-joint stud bolt
Vehicle manufacturer's specifications

OPERATION # 1 REMOVE UPPER CONTROL ARM ASSEMBLY

Procedure:	Evaluation: 3 2 1 N
1. Using proper jacking techniques, place a floor jack under the center of main crossmember. Raise vehicle and place jack stands under frame at cowl area. Set parking brake. Put automatic transmissions in park, manual in first.	___ ___ ___ ___
2. Remove tire and wheel assembly and turn front of wheel outboard as far as possible.	___ ___ ___ ___
3. Remove the cotter pin from upper ball-joint stud.	___ ___ ___ ___
4. With proper wrench, loosen the nut two complete turns.	___ ___ ___ ___
5. Break the joint loose between the tapered ball stud and tapered hole in the steering knuckle by striking sharply with a heavy hammer or a hammer and driving bar on steering knuckle.	___ ___ ___ ___

(NOTE: A special removal tool may be used with the instructor's guidance. Spring tension will aid in loosening ball stud.)

Procedure: **Evaluation:**
3 2 1 N

6. Place floor jack under lower arm at spring pad location and as far outboard as possible to raise and relieve spring tension. ___ ___ ___ ___

   (NOTE: On some models it is necessary to remove backing plate/dust cover in order for ball joint to have clearance.)

7. Remove the ball stud nut and bolts attaching upper inner control arm shaft ___ ___ ___ ___

   (NOTE: If caster-camber shims are used, keep the two shim packs separated to aid reassembly and alignment).

8. Remove the upper control arm assembly. ___ ___ ___ ___

9. Reverse procedure for re-installation ___ ___ ___ ___

   (NOTE: This procedure will work for coil spring or torsion bar front suspensions).

   Average of above evaluations ___ ___ ___ ___

OPERATION # 2 REMOVE LOWER CONTROL ARM ASSEMBLY (COIL SPRING)

(NOTE: On some models it is necessary to remove backing plate/dust cover in order for ball joint to have clearance.)

Procedure: **Evaluation:**
3 2 1 N

1. Perform steps #1 and #2 on Operation #1. ___ ___ ___ ___

2. Remove shock absorber. ___ ___ ___ ___

   (On some models, disconnect only the lower end and push it up out of the way.)

3. Disconnect stabilizer/sway bar at lower control arm attaching point. ___ ___ ___ ___

4. Remove cotter pin from lower ball joint stud and with proper wrench, loosen nut two complete turns. ___ ___ ___ ___

Procedure: **Evaluation:**
3 2 1 N

5. Break joint loose between tapered ball stud and tapered hole in the steering knuckle by striking steering knuckle sharply with a heavy hammer and driving bar. ___ ___ ___ ___

   (NOTE: Special ball stud removal tool may be used with instructor's supervision).

6. Place a floor jack under the control arm as far outboard as possible to relieve spring tension. ___ ___ ___ ___

7. Remove ball stud nut. ___ ___ ___ ___

8. Lower jack until all spring tension is released. ___ ___ ___ ___

   (NOTE: On some models, an appropriate spring compressor is necesary in order to remove the spring.)

9. Remove nuts from the lower control arm and remove lower control arm from vehicle. ___ ___ ___ ___

10. Reverse the procedure to re-install lower control arm. ___ ___ ___ ___

    (NOTE: Tighten all nuts to factory specifications and install cotter pins as required).

Average of above evaluations* ___ ___ ___ ___

(*The averages for Operations 1 and 2 should be averaged. This average is the evaluation for Competency W3 "Remove and re-install front suspension systems" if an SLA suspension with coil springs was used. If an SLA suspension with torsion bars was used, average operation # 1 and operation # 3. This average may also be used as the evaluation for Competency W6 "Service suspension systems.")

ADDITIONAL OPERATIONS FOR EVALUATION

Procedure: **Evaluation:**
3 2 1 N

11. After re-installation of both upper and lower control arms, service brake system** ___ ___ ___ ___

(**This average is the evaluation for Competency W11 "Service brake system.")

TORSION BAR

OPERATION # 3 REMOVE LOWER CONTROL ARM ASSEMBLY (TORSION BAR)

Procedure: **Evaluation:**
3 2 1 N

1. Perform steps #1 and #2 on Operation # 1. ___ ___ ___ ___

2. Remove drum and brake backplate or disc caliper, rotor and dust cover assembly according to service manual procedure. ___ ___ ___ ___

3. Remove shock absorber. ___ ___ ___ ___

4. Disconnect stabilizer/sway bar at lower control arm attaching point. ___ ___ ___ ___

5. Remove cotter pin from lower ball joint stud and with proper wrench, loosen nut two complete turns. ___ ___ ___ ___

6. Break joint loose between tapered ball stud and tapered hole in the steering knuckle by striking steering knuckle sharply with a heavy hammer and driving bar. ___ ___ ___ ___

   (NOTE: Special ball stud removal tool may be used with instructor's supervision).

7. With air impact or appropriate tool, loosen all tension from tension/height ajusting bolt. ___ ___ ___ ___

8. Place a floor jack under the lower control arm and raise to relieve tension. Remove nut and lower jack. ___ ___ ___ ___

9. Remove retainer from torsion bar rear socket area, mark torsion bar location to lower control arm with masking tape. ___ ___ ___ ___

10. Remove cotter pin from lower control arm attaching bolt and remove nut. ___ ___ ___ ___

11. Remove brake reactor rod at lower control arm location. ___ ___ ___ ___

12. Remove torsion bar; then slide lower control arm to rear of crossmember and remove from vehicle. ___ ___ ___ ___

Procedure:	**Evaluation:** **3 2 1 N**
13. Reverse procedure to re-install.	___ ___ ___ ___

(NOTE: Tighten all nuts to factory specifications, install cotter pins as required, and set static height to factory specifications.)

Average of above evaluations* ___ ___ ___ ___

(*The averages for operations one and three should be averaged. This average is the evaluation for Competency W3 "Remove and re-install front suspension systems," if an SLA suspension with torsion bars was used. It also may be used as the evaluation for Competency W6 "Service suspension systems.")

ADDITIONAL OPERATIONS FOR EVALUATION

14. After re-installation of both upper and lower control arms, service brake system** ___ ___ ___ ___

(**This average is the evaluation for Competency W11 "Service brake system.")

UNIT I

JOB SHEET #2, LESSON ONE

REMOVE AND REPLACE MACPHERSON-STRUT FRONT SUSPENSION

Equipment

Vehicle with true MacPherson-strut suspension
Floor jack
Jack stands
Pinchweld clamps and crosstube (optional)
Common hand and power tools
Vehicle specifications

(NOTE: Always consult manufacturer's recommendations for variations in procedures and special cautions.)

Procedure:		**Evaluation:**			
		3	**2**	**1**	**N**
1.	Jack up vehicle and place on safety stands according to recommended procedures.	___	___	___	___
2.	Remove wheel.	___	___	___	___
3.	Remove tie rod from steering arm.	___	___	___	___
4.	Separate brake line from brake hose or remove caliper assembly and attach to apron in such a way there is no pressure on the brake line.	___	___	___	___
5.	Remove brake reactor rod/ stabilizer from lower control arm (if vehicle has one).	___	___	___	___
6.	Remove lower ball joint from lower control arm.	___	___	___	___
7.	Remove upper strut attaching bolts.	___	___	___	___
8.	Refer to manufacturer's specs for additional steps if required.	___	___	___	___
9.	Reverse procedure for re-installing.	___	___	___	___
10.	Check alignment angles.	___	___	___	___
	Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency W3 "Remove and reinstall front suspension system," if MacPherson-strut suspension was used. It may also be used as the evaluation for Competency W6 "Service suspension systems.")

ADDITIONAL OPERATIONS FOR EVALUATION

Procedure:	**Evaluation:** **3 2 1 N**
11. Service brake system**	___ ___ ___ ___

(**This average is the evaluation for Competency W11 "Service brake system" if MacPherson-strut suspension is used).

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT I: SUSPENSION SYSTEMS

LESSON 2: IDENTIFYING REAR SUSPENSION SYSTEMS

I. Terms and definitions

A. Axle housing – In front engine, rear-wheel-drive vehicles, the housing which supports the weight of the vehicle on the rear tires, and which contains the drive axles and differential.

B. Hotchkiss drive – The type of rear suspension system employing leaf springs to absorb rear axle housing torque and provides for jounce and rebound.

C. Independent rear suspension – Rear suspension in which there is no axle housing. Each wheel can move individually.

D. Lateral control rod – Rod attaching the axle housing to the vehicle underbody and used to control lateral movement of the rear axle assembly. In unitized vehicles, it connects the outer end of the control arm to the unitized structure.

E. Leaf Spring – A spring composed of a single flat steelplate, or several plates of different lengths placed one atop the other.

II. Principles of rear suspensions

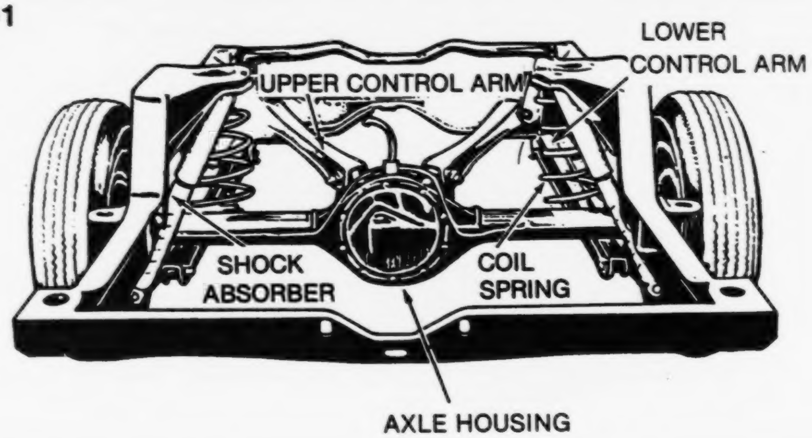
(NOTE: Following are six basic types of rear suspension systems. There are variations, particularly in the case of four-wheel-drive vehicles and various trucks).

1. Rear suspensions are divided by two basic vehicle types:
   a. Those for front engine, rear-wheel-drive vehicles.
   b. Those for front engine, front-wheel-drive vehicles with transverse engine mounting
2. Types of rear suspensions in front engine, rear-wheel-drive vehicles:
   a. Coil spring with axle housing
   b. Leaf spring with axle housing
   c. Independent drive axle
3. Types of rear suspensions in front engine, front-wheel-drive vehicles.
   a. Modified MacPherson-strut
   b. True MacPherson-strut
   c. Torsion beam

III. Parts and functions of rear suspension systems

A. Coil spring, front engine, rear-wheel-drive (FIG. 2-1)

FIGURE 2-1



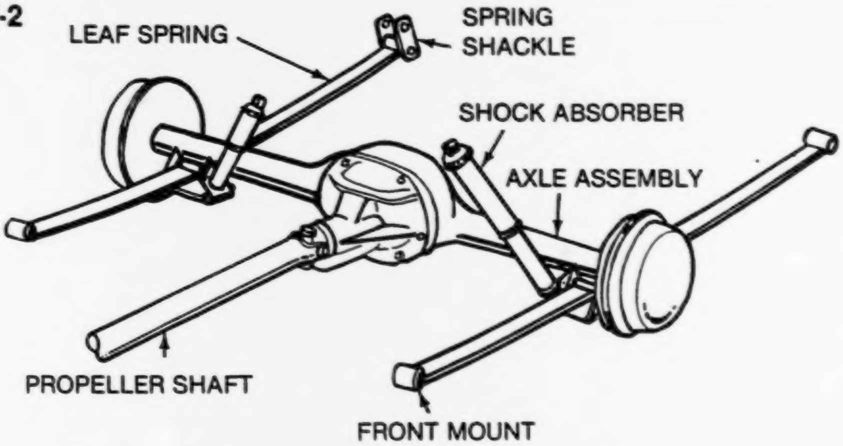
1. Axle housing
    a. Contains drive axle
    b. Supports wheels
2. Lower control arms
    a. Provide lateral connecting link between axle housing and vehicle body or frame
    b. Allow vertical movement of axle housing
3. Upper control arms or lateral control rods
    a. Controls lateral movement of axle housing and sideways movement

    (NOTE: Some systems use upper control A-arms and some systems use lateral control rods. They are different designs serving the same purpose.)
4. Coil spring
    a. Located between axle housing and frame
    b. Allows for jounce and rebound
    c. Supports weight of vehicle
5. Shock absorber
    a. Usually located outside coil spring; attached to same components as spring through various mountings.

b. Provides control of jounce and rebound

B. Leaf spring, front engine, rear-wheel-drive (FIG. 2-2)

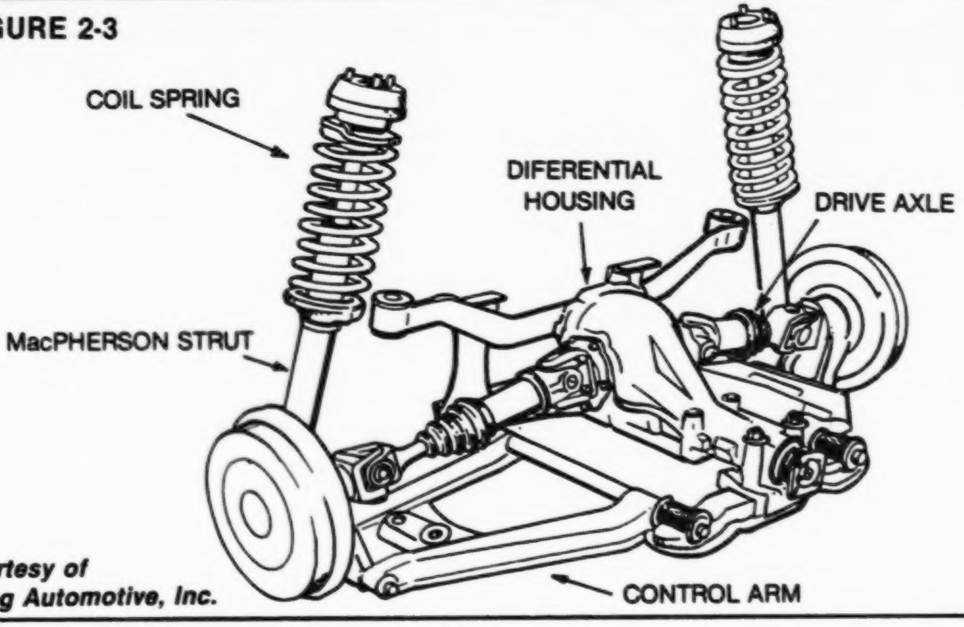
FIGURE 2-2


LEAF SPRING
SPRING SHACKLE
SHOCK ABSORBER
AXLE ASSEMBLY
PROPELLER SHAFT
FRONT MOUNT

1. Axle housing
    a. Contains drive axle
    b. Supports wheels
2. Leaf spring
    a. Provides connecting link between axle housing and vehicle body
    b. Allows vertical movement of axle housing by allowing for jounce and rebound
    c. Supports weight of vehicle
3. Shock absorber
    a. Attached to axle housing and vehicle frame
    b. Controls jounce and rebound

C. Independent drive axle (FIG. 2-3)

FIGURE 2-3



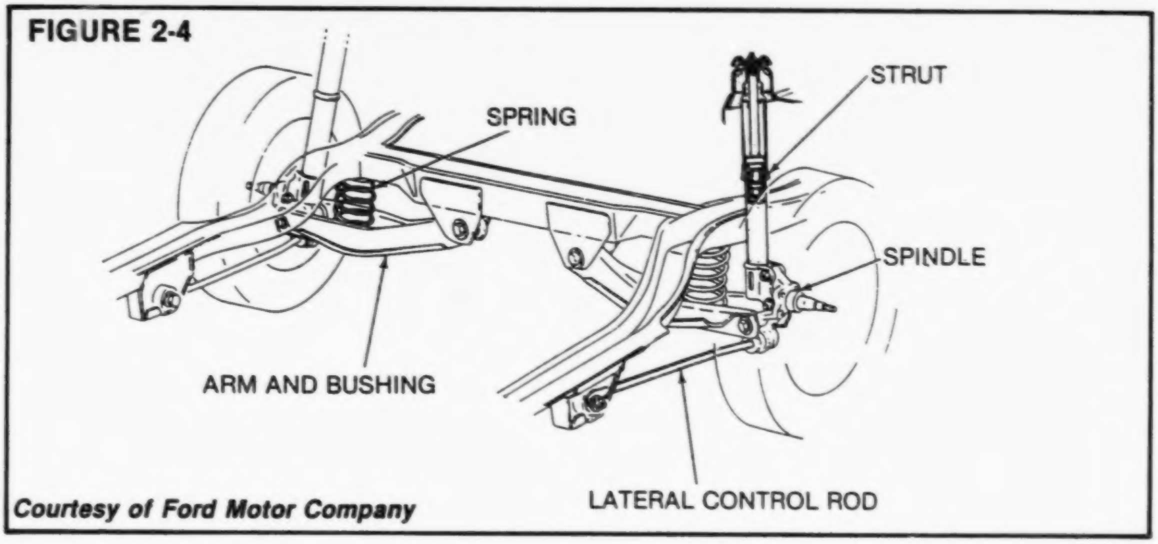
Courtesy of Moog Automotive, Inc.

1. Differential housing
   a. Contains differential
   b. Connected directly to vehicle body or frame
2. MacPherson-strut
   a. Provides connecting link between wheel assembly and vehicle body
   b. Controls jounce and rebound
3. Coil spring
   a. Supports weight of vehicle
   b. Allows for jounce and rebound
4. Drive axles
   a. Drives wheels by connecting differential to wheels using universal joints
5. Control arms
   a. Allow vertical movement of wheels for jounce and rebound
   b. Connected between vehicle frame and wheel assembly

   (NOTE: Some independent rear-wheel-drives use a coil spring and shock absorber instead of a MacPherson-strut).

D. Modified MacPherson-strut (FIG. 2-4)

FIGURE 2-4



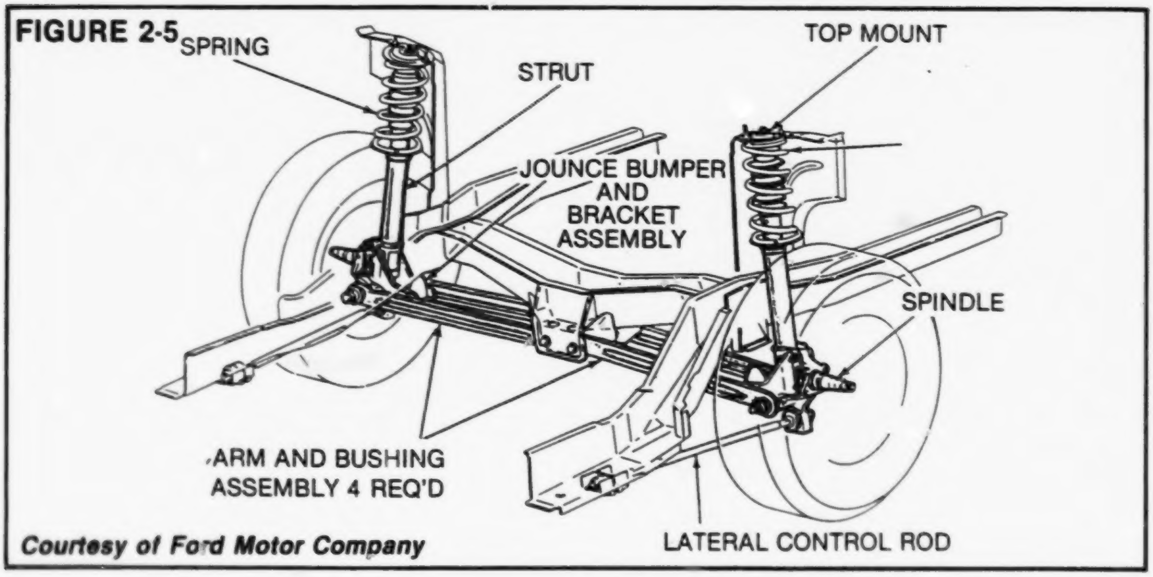
Courtesy of Ford Motor Company

1. Control arm
    a. Attaches wheel spindle/strut assembly to crossmember or directly to unibody
    b. Allows vertical movement of wheels
2. Coil spring
    a. Located between control arm and crossmember or reinforced area of unibody
    b. Allows for jounce and rebound
    c. Supports weight of vehicle
3. Wheel spindle
    a. Attaches wheel to control arm and strut
    b. Allows rotation of wheel
4. Strut assembly
    a. Located vertically between strut tower (or reinforced area of quarter panel) and wheel spindle
    b. Controls jounce and rebound
    c. Supports wheel in vertical position

5. Lateral control rod
   a. Attached between wheel spindle and frame
   b. Assists control arm in preventing forward/ backward movement of wheels

D. True MacPherson-strut (FIG. 2-5)

FIGURE 2-5


SPRING
STRUT
TOP MOUNT
JOUNCE BUMPER AND BRACKET ASSEMBLY
SPINDLE
ARM AND BUSHING ASSEMBLY 4 REQ'D
LATERAL CONTROL ROD

Courtesy of Ford Motor Company

1. Control arms
   a. Attach strut assemblies to crossmember or directly to unibody
   b. Allow vertical movement of wheels

      (NOTE: Some vehicles have one control arm on each side and some vehicles have two parallel control arms on each side).

2. Coil spring
   a. Located on upper portion of strut
   b. Allows for jounce and rebound
   c. Supports weight of vehicle

3. Wheel spindle
   a. Attaches wheel to control arm, strut and tie rod
   b. Allows rotation of wheel

4. MacPherson-strut

   a. Located between strut tower (or reinforced area of quarter panel) and wheel spindle

   b. Provides damping of jounce and rebound

   c. Supports wheel in vertical position

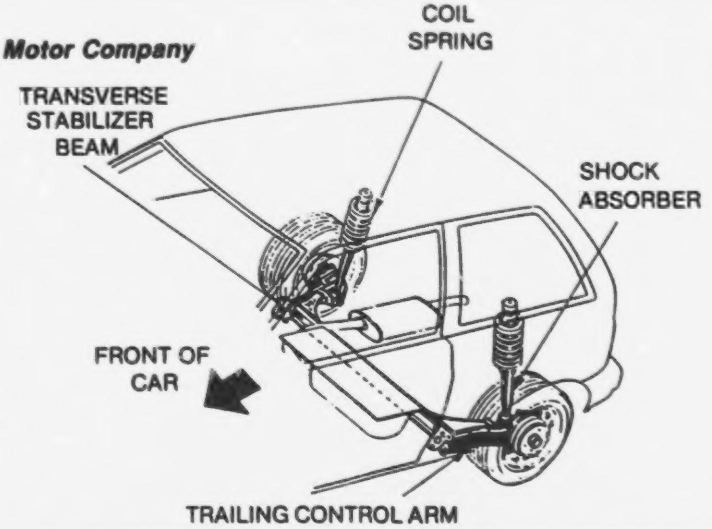
5. Lateral control rod

   a. Attached between wheel spindle and frame

   b. Prevents lateral movement of wheels

E. Torsion beam (FIG. 2-6)

FIGURE 2-6
Courtesy of Ford Motor Company


COIL
SPRING
TRANSVERSE
STABILIZER
BEAM
SHOCK
ABSORBER
FRONT OF
CAR
TRAILING CONTROL ARM

1. Control arms (trailing arms)

   a. Allow vertical movement of wheels

   b. Provide connecting link between wheel spindle assembly and vehicle body

2. Coil spring

   a. Located on MacPherson-strut

   b. Allows for jounce and rebound

   c. Supports weight of vehicle

3. Transverse stabilizer beam (torsion beam)

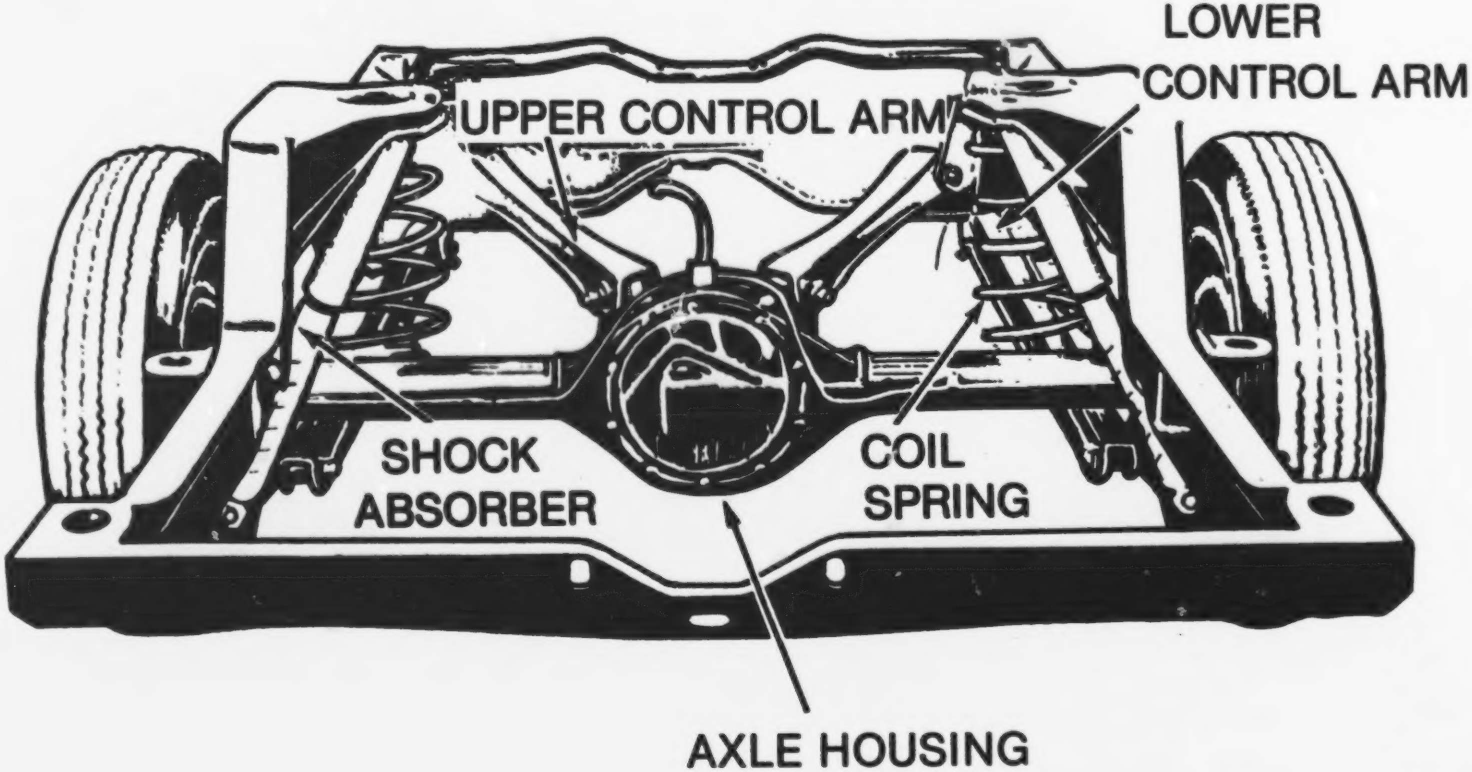
   a. Prevents tipping of vehicle in turns

   b. Allows some independent movement of each wheel

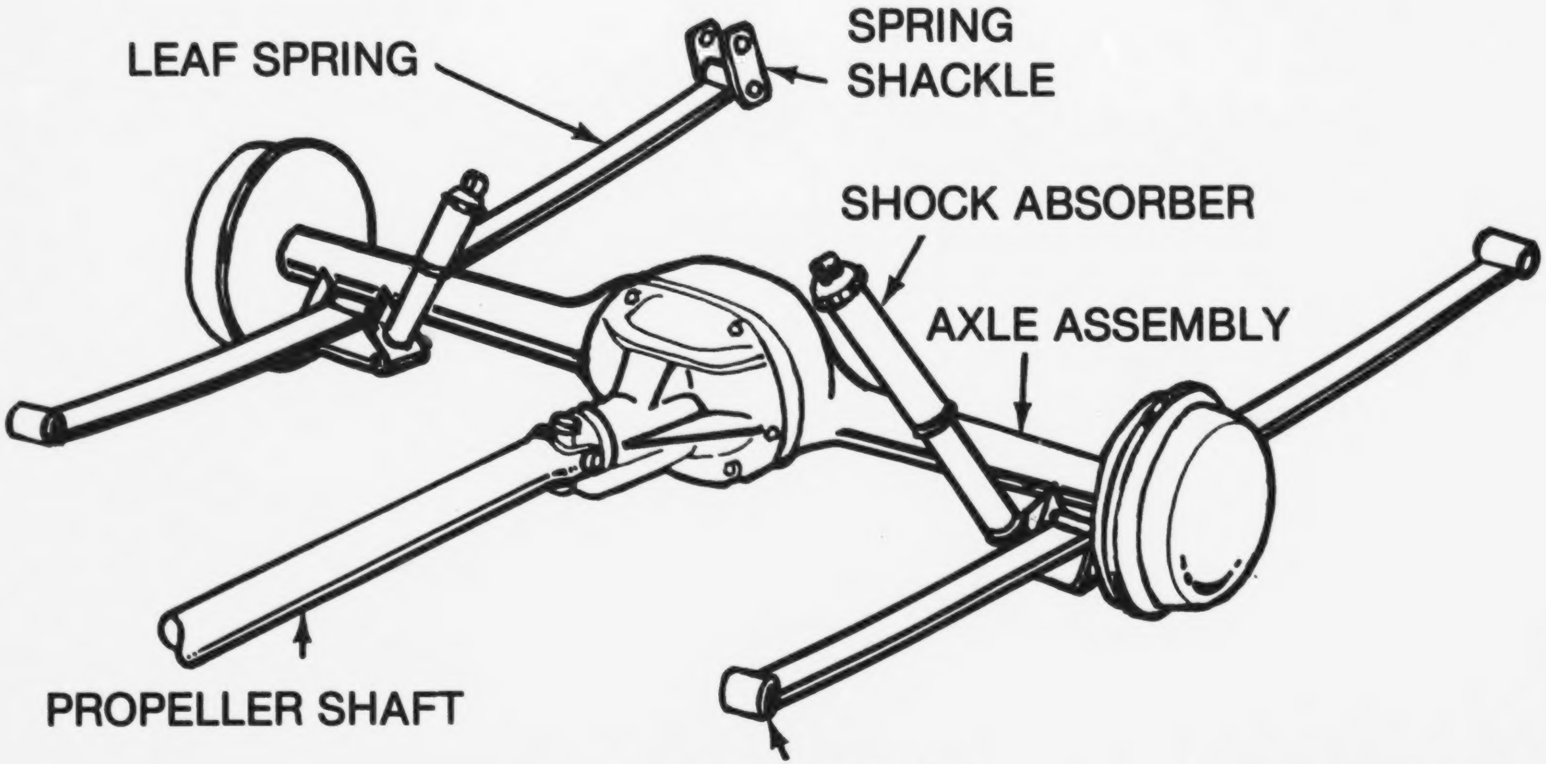
1065

4. MacPherson-strut
    a. Connected between wheel assembly and vehicle body structure
    b. Controls jounce and rebound

Solid Axle, Coil Spring


LOWER CONTROL ARM
UPPER CONTROL ARM
SHOCK ABSORBER
COIL SPRING
AXLE HOUSING

Solid Axle, Leaf Spring


LEAF SPRING
SPRING SHACKLE
SHOCK ABSORBER
AXLE ASSEMBLY
PROPELLER SHAFT
FRONT MOUNT

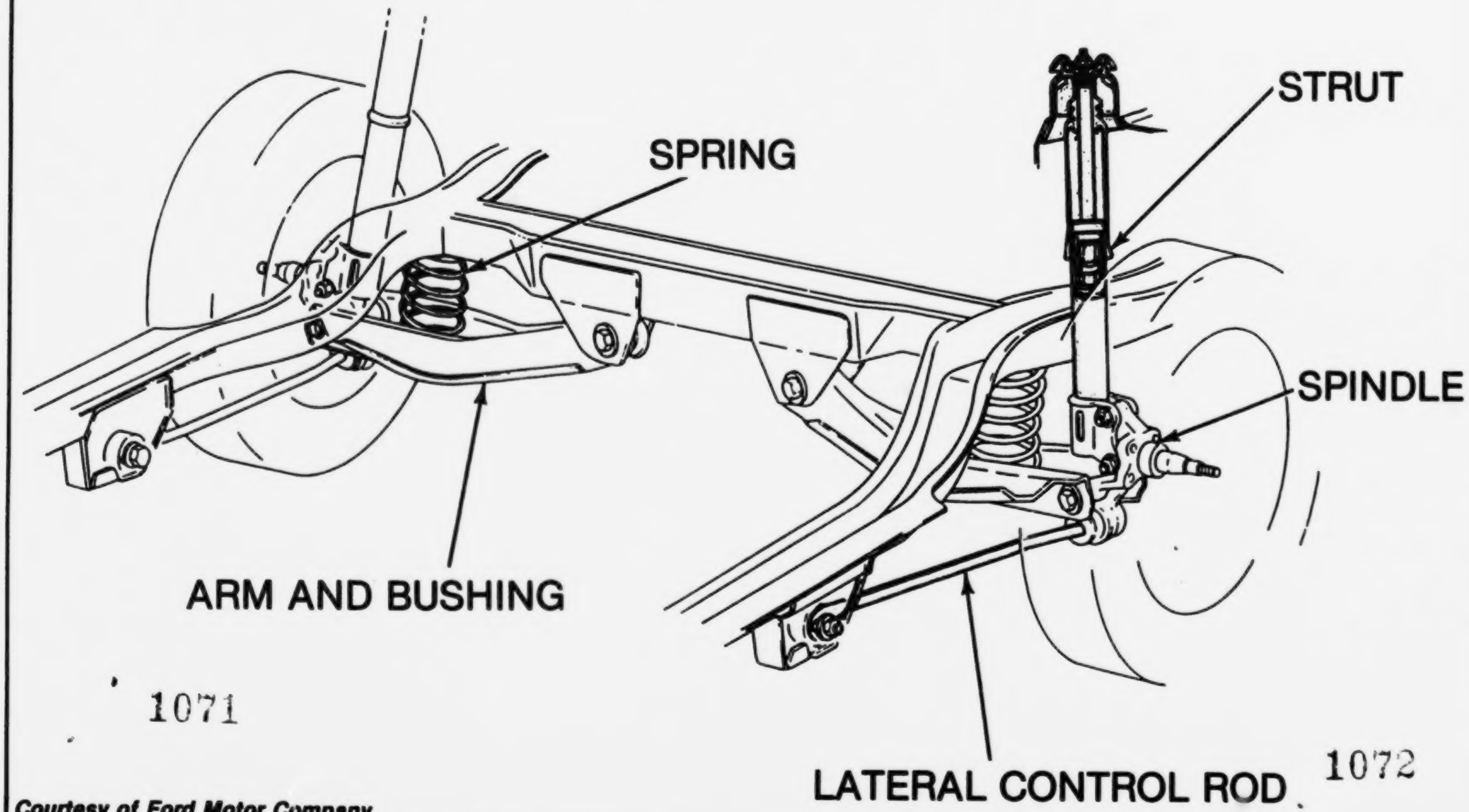
1070

1069

TM 2

I-FRAME - 37

Modified MacPherson Strut

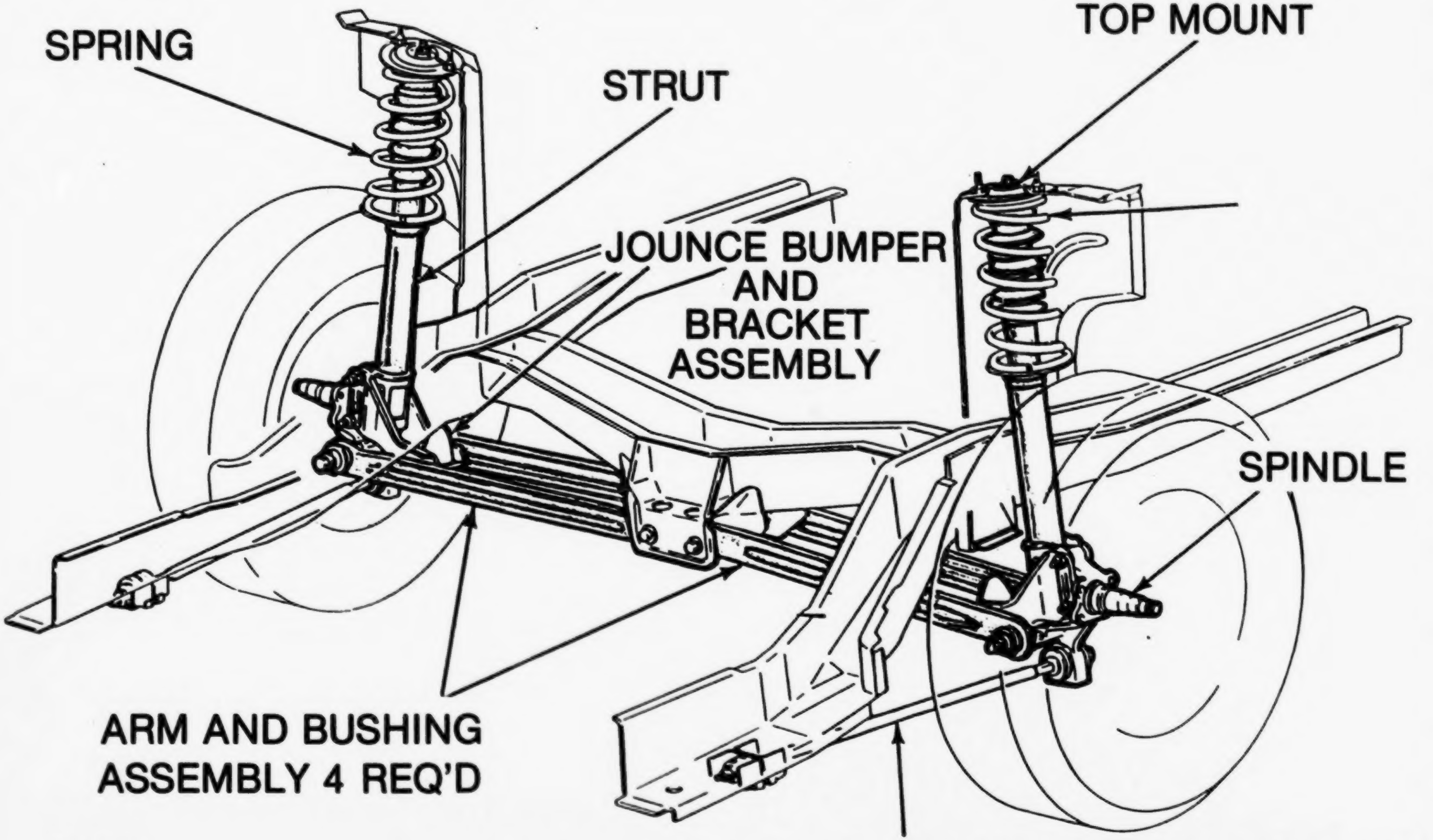

STRUT
SPRING
SPINDLE
ARM AND BUSHING
LATERAL CONTROL ROD

1071

1072

Courtesy of Ford Motor Company

True MacPherson Strut

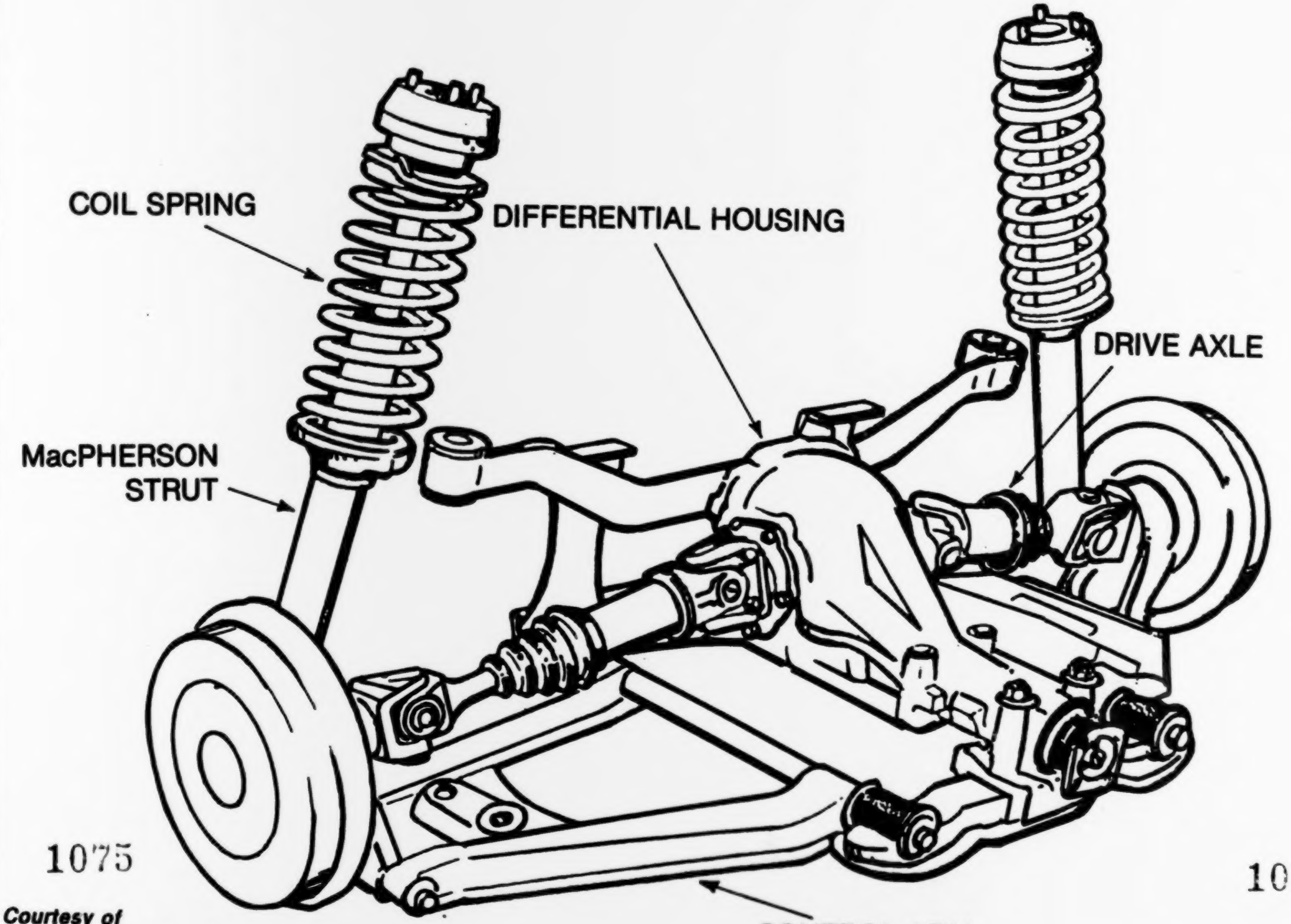

SPRING
STRUT
TOP MOUNT
JOUNCE BUMPER AND BRACKET ASSEMBLY
SPINDLE
ARM AND BUSHING ASSEMBLY 4 REQ'D
LATERAL CONTROL ROD

1073

1074

Courtesy of Ford Motor Company

Independent Drive Axle

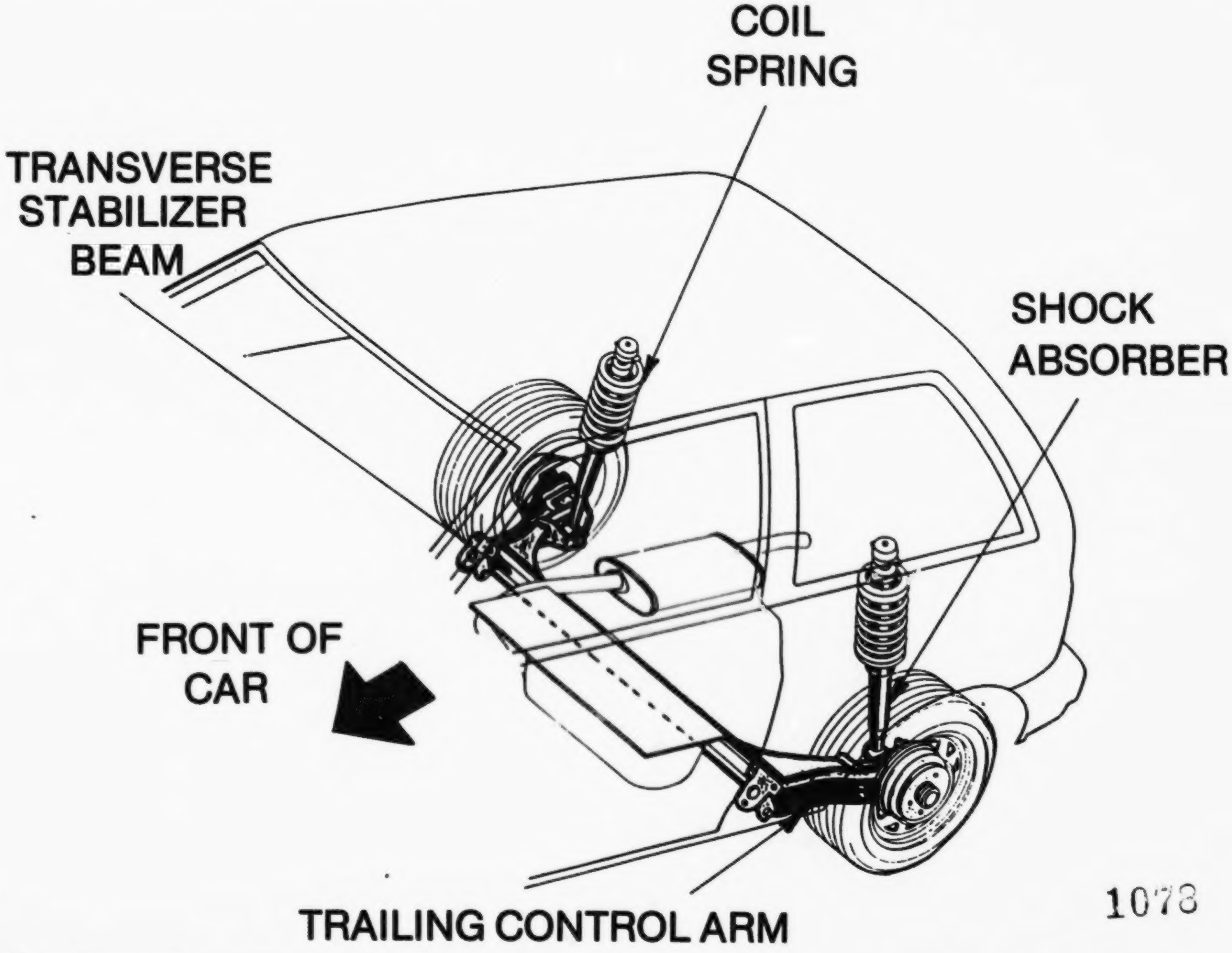

COIL SPRING
DIFFERENTIAL HOUSING
DRIVE AXLE
MacPHERSON STRUT
CONTROL ARM

1075

1076

Courtesy of
Moog Automotive, Inc.

Torsion-Beam Suspension


COIL SPRING
TRANSVERSE STABILIZER BEAM
SHOCK ABSORBER
FRONT OF CAR
TRAILING CONTROL ARM

1077

1078

Courtesy of Ford Motor Company

UNIT I

JOB SHEET #1, LESSON TWO

REMOVE AND REPLACE REAR SUSPENSION SYSTEMS

(Note: Due to the wide variety of rear suspension configurations, manufacturer's specifications and shop manuals must always be consulted. Your instructor will provide proper reference manuals and equipment and will review the exact steps of procedure as instructor deems necessary for the safe completion of the assignment)

Equipment

(NOTE: This is a basic list of equipment. Variations or additional equipment will be required depending on vehicle).

Lifting, jacking and supporting devices for vehicle
Spring compressors
Portable hydraulic jacks and/or jacks designed for removal of axle housing
General hand tools

Procedure:	**Evaluation:** 3	2	1	N
1. Support vehicle properly.	___	___	___	___
2. Remove rear suspension.	___	___	___	___
3. Re-install rear suspension.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average provides the evaluation for Competency W4 "Remove and re-install rear suspension.")

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT I: SUSPENSION SYSTEMS

UNIT I TEST

PART I—FRONT SUSPENSION SYSTEMS

I. Select the best answer from the choices listed.

_____1. The short-arm, long-arm suspension system is associated with (a) foreign cars, (b) rear-wheel drive, frame-body cars, (c) unibody, front-wheel drive cars, (d) frame-body, front wheel drive cars, (e) unibody, rear-wheel drive cars.

_____2. The MacPherson-strut suspension system is associated with (a) American cars, (b) rear-wheel drive, frame-body cars, (c) unibody, front-wheel drive cars, (d) frame-body, front wheel drive cars, (e) unibody, rear-wheel drive cars.

_____3. Which of the following is NOT one of the three functions of a suspension system? (a) cushion road shocks, (b) support weight of vehicle, (c) position wheels, (d) control direction.

_____4. Which of the following is NOT one of the three factors influencing suspension design? (a) load carrying requirements of the vehicle, (b) horsepower of engine, (c) frame design, (d) engine location.

II. Use the correct letter from the diagram to identify the parts in questions 5-12.

_____5. Shock

_____6. Upper control arm

_____7. Upper ball joint

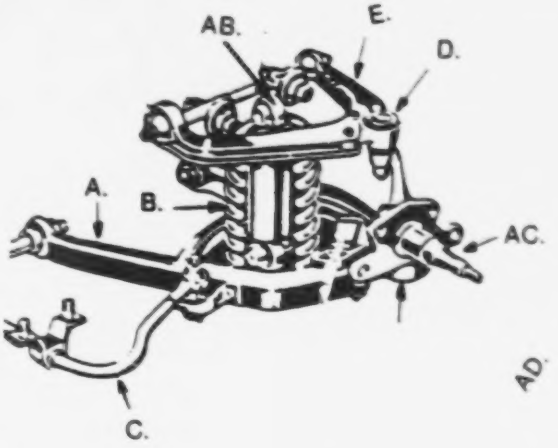
_____8. Knuckle/spindle

_____9. Lower ball joint

_____10. Upper ball joint

_____11. Control rod

_____12. Coil spring



III. Use the correct letter from the diagram to identify the parts in questions 13-20.

_____13. Apron tower

_____14. Tie rod bracket

_____15. Spring

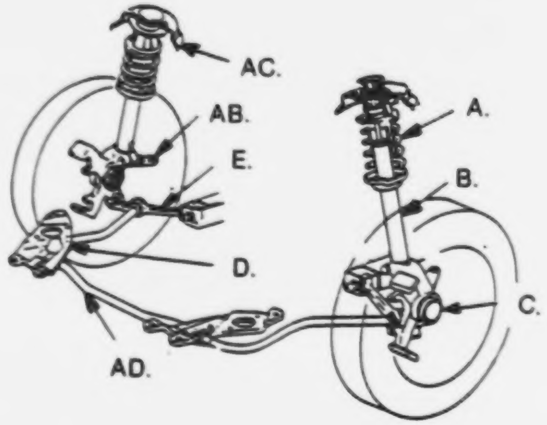
_____16. Control arm

_____17. MacPherson strut

_____18. Sway bar bracket

_____19. Knuckle assembly

_____20. Sway bar



IV. Use the correct letter from the list below to label the diagram for questions 21-28.

_____21. Dust cap

_____22. Upper mount

_____23. Thrust plate

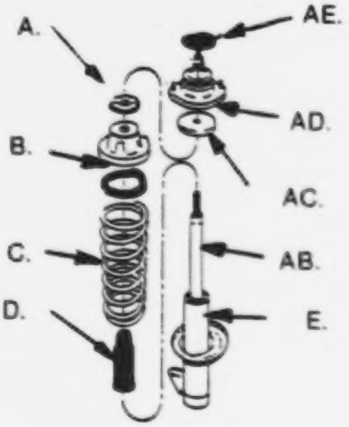
_____24. Shock absorber shaft

_____25. Strut tube

_____26. Front jounce bumper

_____27. Spring

_____28. Spring seat



(NOTE: Completion of this portion of the unit test is the evaluation for Competency W1 "Identify front suspension systems." Of the 28 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, the student should retake this portion of the test.)

PART II--REAR SUSPENSION SYSTEMS

I. Use the correct letter from the list below to label the diagram for questions 29-33.

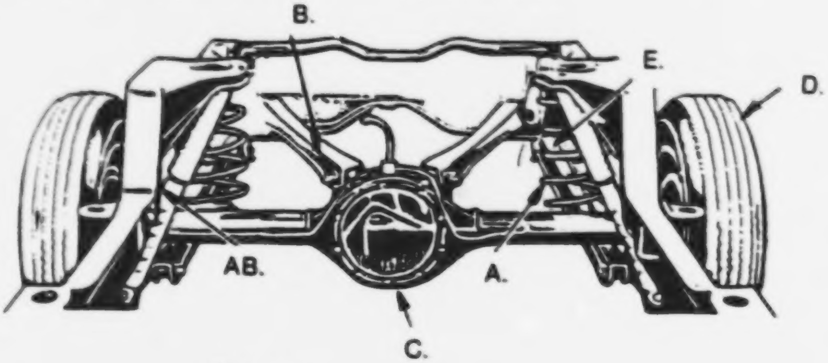
_____29. Upper control arm

_____30. Lower control arm

_____31. Shock absorber

_____32. Axle housing

_____33. Coil spring



II. Use the correct letter from the list below to label the diagram for questions 34-38.

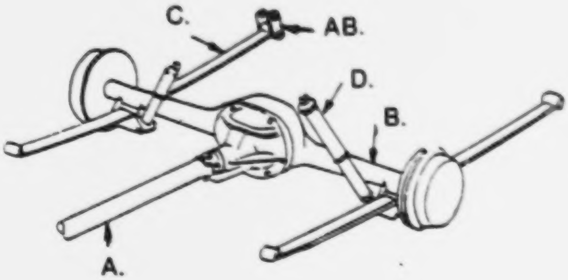
_____34. Leaf spring

_____35. Spring shackle

_____36. Shock absorber

_____37. Axle assembly

_____38. Propeller shaft



III. Use the correct letter from the list below to label the diagram for questions 39-43.

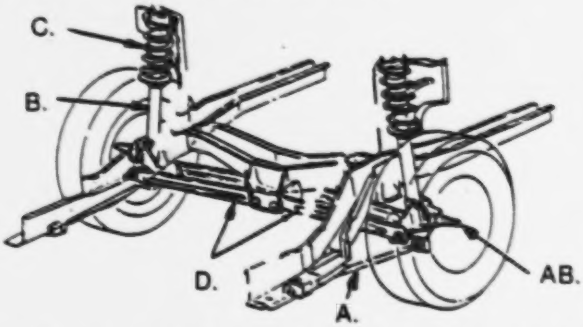
_____39. Spring

_____40. Spindle

_____41. Strut

_____42. Arm-and-bushing assembly

_____43. Lateral control rod



(NOTE: Completion of this portion of the test is the evaluation for Competency W2 "Identify rear suspension systems." Of the 15 questions, _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this portion of the test.)

ANSWERS TO UNIT I TEST

PART I.

1. B
2. C
3. D
4 B

5. AB
6. E
7. D
8. AC
9. AD
10. C
11. A
12. B

13. AC
14. AB
15. A
16. E
17. B
18. D
19. C
20. AD

21. AE
22. AD
23. AC
24. AB
25. E
26. D
27. C
28. B

PART II.

29. E
30. B
31. AB
32. C
33. A

34. C
35. AB
36. D
37. B
38. A

39. C
40. AB
41. B
42. D
43. A

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT II: STEERING SYSTEMS AND FRONT DRIVE TRAINS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify steering systems and front drive trains, and be able to remove and replace front drive trains. Mastery will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Identify terms and definitions (Competency W7, Unit II test)

II. Identify the two basic types of steering systems (Competency W7, Unit II test)

III. Identify operation of conventional system (Competency W7, Unit II test)

IV. Identify operation of rack-and-pinion system (Competency W7, Unit II test)

V. Identify power steering systems (Competency W7, Unit II test)

VI. Demonstrate the ability to service power steering systems (Competency W10, Job Sheet #1)

Lesson 2:

I. Identify terms and definitions (Competency W5, no test)

II. Identify front drive trains and mountings (Competency W5, no test)

III. Identify principles of removal and replacement (Competency W5, no test)

IV. Demonstrate the ability to remove and replace front drive trains (Competency W5, Job Sheet #1)

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT II: STEERING SYSTEMS AND FRONT DRIVE TRAINS

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

1. Lesson 1: Identifying conventional and rack-and-pinion steering systems

    a. Information outline

    b. Transparency masters

        TM#1: Conventional steering system
        TM#2: Rack and pinion steering system

    c. Job Sheet

        JS#1: Service power steering systems

2. Lesson 2: Front drive train removal

    a. Information outline

    b. Job sheets

        JS#1: Remove and replace front drive trains

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. There is no competency for replacement of the steering system or components. If this were to be done independent of removing and replacing the front suspension, it could be added as a new competency to the student's profile.

REFERENCES USED IN WRITING THIS UNIT

1. Blackhawk Automotive. *New Science of Unibody Repair*. Blackhawk Automotive. Milwaukee, WI. 1984.

2. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing*. Second edition. McGraw-Hill. New York, NY. 1986.

3. Czapskie, George S., et. al. *Auto Body Repair.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1977.

4. Downing, Ronald. *Auto Mechanics. Automotive Suspension and Steering Systems and Service Procedures.* Instructional Materials Laboratory, University of Missouri. Columbia, MO. 1981.

5. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL. 1984.

6. Ford Parts and Service Division. *Front and Rear Suspension systems, Certified Training Program, 1977-1.* Ford Motor Company. Dearborn, MI. 1984.

7. Hilley, Robert. *Automotive Frame Repairer.* Curriculum & Instructional Materials Center. Oklahoma State Board of Vocational and Technical Education. Stillwater, OK. 1986.

8. Inter-Industry Conference on Auto Collision Repair. Unibody Auto Collision Repair Training Program. *Suspension and Steering Systems.* D.I.A. Communications. Des Plains, IL. 1981.

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12. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

13. Scharff, Robert. *Motor Auto Body Repair.* Delmar Publishers, Inc. Albany, NY. 1988.

14. Toboldt, Bill. *Auto Body Repairing and Repainting.* The Goodheart-Willcox Co. Inc. South Holland, IL. 1982.

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MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT II: STEERING SYSTEMS AND FRONT DRIVE TRAINS

LESSON ONE: IDENTIFYING STEERING SYSTEMS

I. **Terms and definitions**

A. Ball stud – A stud with a ball-shaped end. Used in steering linkages to connect the pitman arm to the linkages, or to connect tie rods.

B. Conventional steering systems – Steering systems used before the development of rack-and-pinion systems. Used a pitman arm and idler arm assembly to connect the steering gear and tie rods.

C. Energy-absorbing steering column – Steering column designed to collapse upon impact to reduce the chance of injury to the driver.

D. Idler arm and bracket – A steering system component in which a short idler arm is mounted on the passenger side of the vehicle so that it is parallel to the pitman arm. Also called parallelogram steering.

E. Linkage-type power steering – A type of power steering in which the power-steering units (power cylinder and valve) are part of the steering linkage.

F. Pinion gear – The smaller of two meshing gears, part of the pinion-shaft assembly.

G. Pitman arm – The arm that is connected on the steering gear pitman/sector shaft and the steering linkage in conventional steering systems.

H. Rack-and-pinion steering – Steering system using rack gear and a pinion gear in the steering gear assembly.

I. Recirculating-ball-and-nut steering gear – A type of steering gear in which a nut, meshing with a gear sector, is assembled on a worm gear. Balls circulate between the nut and worm threads.

J. Sector gear – A gear that is not a complete circle. Specifically, the gear on the pitman arm shaft in many steering systems.

K. Steering gear – The part of the steering system located at the lower end of the steering shaft which turns the rotary motion of the steering wheel into the force for steering the vehicle wheels.

L. Steering shaft – Shaft connecting the steering gear to the steering wheel.

M. Steering system – Assembly enabling the driver to change the direction of vehicle movement, and maintain the direction of the vehicle.

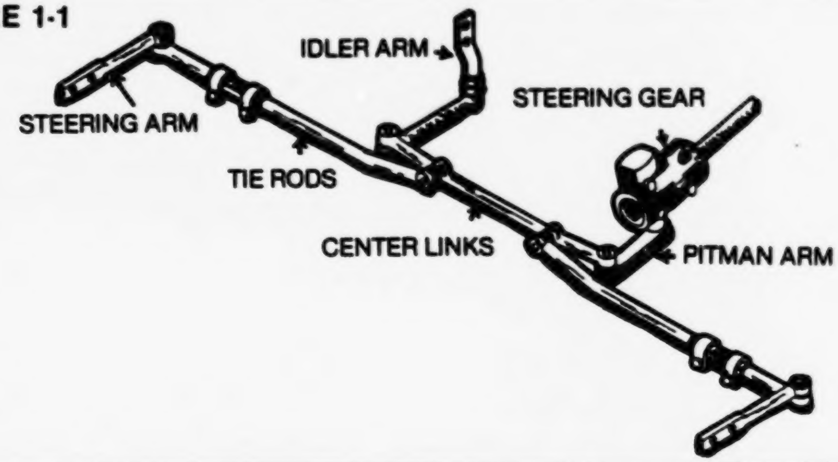
N. Tie-rod end – A socket and ball stud in a housing which rotates and tilts to transmit steering action under all conditions.

O. Tie rod – The rods that attach steering gear assembly to the steering arms by means of the tie rod ends.

II. The two basic types of steering systems

A. Conventional (such as the Saginaw system used by GM, Ford and Chrysler in many of their models) (FIG. 1-1)

FIGURE 1-1


IDLER ARM
STEERING GEAR
STEERING ARM
TIE RODS
CENTER LINKS
PITMAN ARM

1. Used on most American cars prior to 1980

2. Uses pitman arm and center link to connect steering gear to tie rods. Also known as the parallelogram system.

   (NOTE: The name "parallelogram" comes from the geometric shape formed by the tie rods and steering arms; every turn angle forms a parallelogram).

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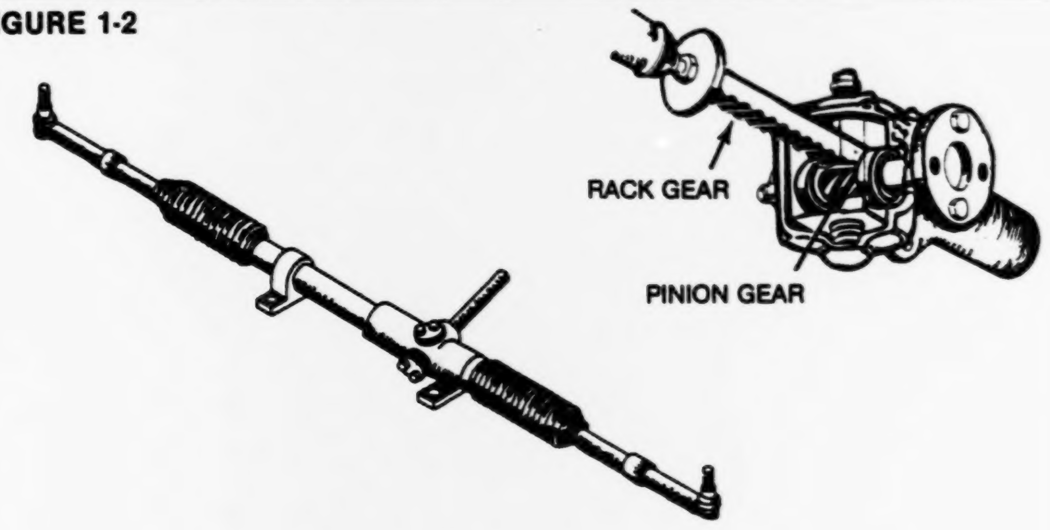
B. Rack and pinion (FIG. 1-2)

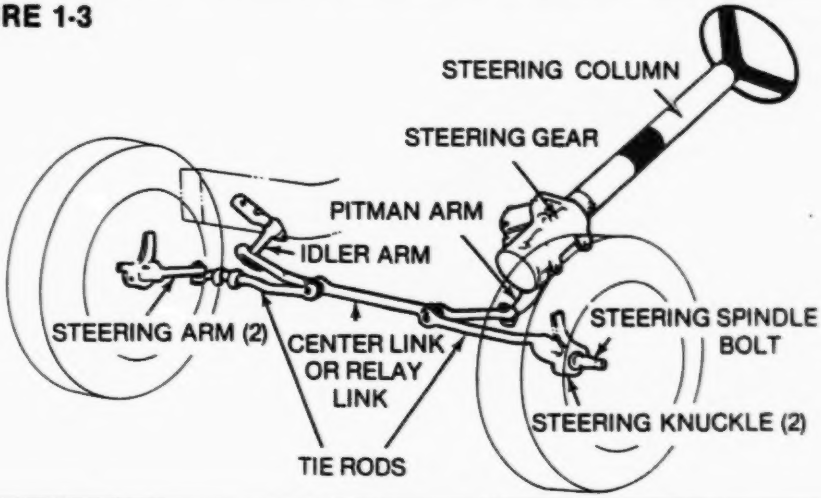
FIGURE 1-2



1. Used on most unibody vehicles since 1980
2. Lighter than conventional system; uses fewer parts
3. Uses a rack gear and a pinion gear to incorporate tasks of pitman arm, center link and steering gear

III. Functions of parts of conventional system (FIG. 1-3)

FIGURE 1-3


STEERING COLUMN
STEERING GEAR
PITMAN ARM
IDLER ARM
STEERING ARM (2)
CENTER LINK OR RELAY LINK
STEERING SPINDLE BOLT
STEERING KNUCKLE (2)
TIE RODS

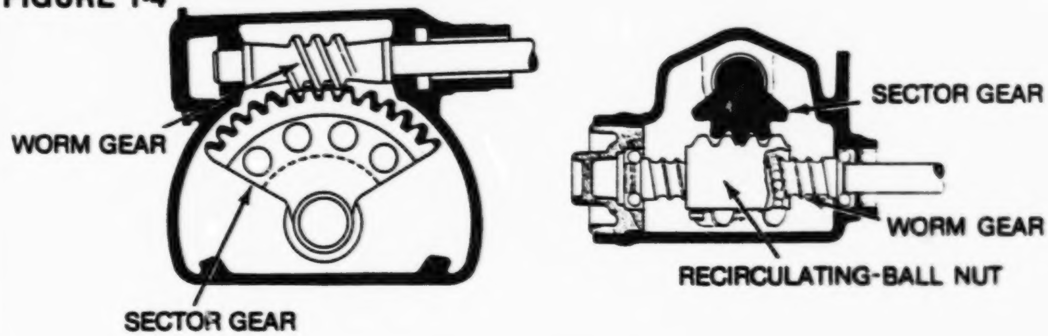
A. Steering column

1. Houses steering shaft, which connects steering wheel to steering gear
2. Extends from steering gear into passenger compartment

B. Steering gear

1. Configuration of gears in a housing providing link between steering wheel and pitman arm
2. May be worm-and-sector-type or recirculating-ball nut and worm-type (FIG. 1-4)

FIGURE 1-4


WORM GEAR
SECTOR GEAR
SECTOR GEAR
WORM GEAR
RECIRCULATING-BALL NUT

C. Pitman arm

1. Connects steering gear to center link

2. Controls angle of turn

D. Center link

1. Connects pitman arm and idler arm to tie rods

2. Allows independent movement of tie rods

E. Idler arm

1. Connects end of center link opposite pitman arm to stationary point on vehicle

2. Allows movement of center link while keeping center link and tie rods in proper position

F. Tie rods

1. Connect center link to steering arms

2. Allow independent jounce and rebound of wheels

G. Steering arm

1. Connects tie rod to steering knuckle. (Some steering knuckles include the steering arm.)

2. Shape of steering arm sets toe angle of wheels in turns (see Unit III)

H. Steering knuckle

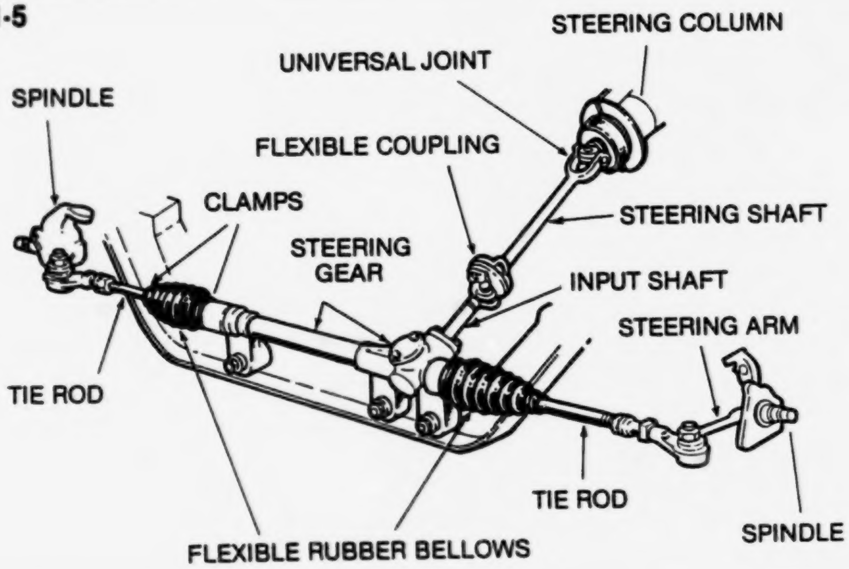
1. Connects steering arm and upper and lower control arm to wheel

2. Allows wheels to rotate and turn

(NOTE: Conventional systems differ among manufacturers. Always consult vehicle service manual.)

IV. Functions of parts of rack-and-pinion steering (FIG. 1-5)

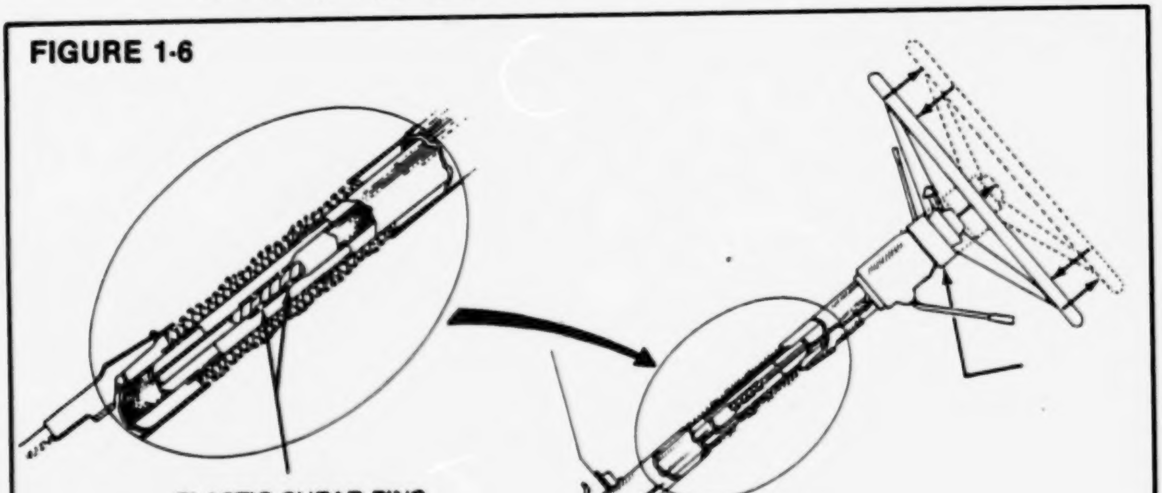
FIGURE 1-5


STEERING COLUMN
UNIVERSAL JOINT
SPINDLE
FLEXIBLE COUPLING
CLAMPS
STEERING SHAFT
STEERING GEAR
INPUT SHAFT
STEERING ARM
TIE ROD
TIE ROD
SPINDLE
FLEXIBLE RUBBER BELLOWS

A. Steering column

1. Houses steering shaft
2. Extends from steering gear into passenger compartment
3. Due to federal regulations, all vehicles since the late 1960s have energy-absorbing steering columns, which must be checked for damage routinely in collision repair. (FIG. 1-6)

FIGURE 1-6


PLASTIC SHEAR PINS

B. Steering shaft and universal joint

   1. Connects steering wheel to steering gear

   2. Universal joint is used in most rack-and-pinion systems to position the steering gear closer to the passenger compartment without changing the angle of the steering column.

C. Steering gear (rack-and-pinion assembly)

   1. Link between steering shaft and tie rods

   2. Rack-and-pinion assembly provides in-line link with tie rods.

D. Tie rods

   1. Connect rack-and-pinion assembly to steering arms using tied rod ends

   2. Allow independent jounce and rebound of wheels

E. Steering arm

   1. Connects tie rod to steering knuckle

   2. Design of steering arm sets toe angle of wheels in turns

F. Steering knuckle/spindle

   1. Connects steering arm and wheel to lower control arm and strut

   2. Allows wheels to rotate and turn

V. **Power steering systems**

A. Many cars have power steering systems, which use a hydraulic pump driven by the vehicle's engine to provide easier steering.

B. There are several types of power steering systems. Consult vehicle service manual on vehicles with power steering.

C. Servicing power steering systems

   1. In a collision, the power steering system can be damaged.

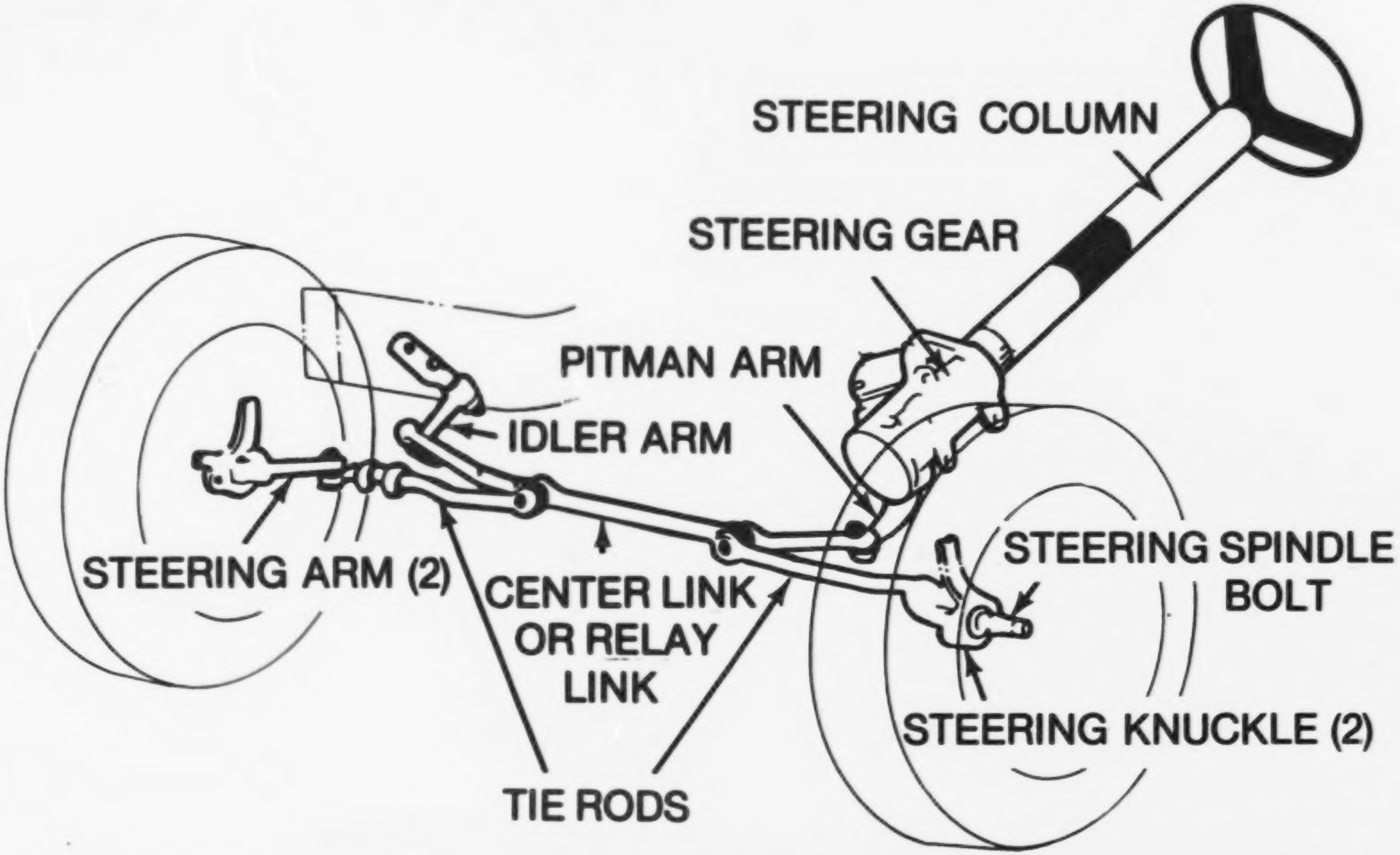
   2. Drive belts, pulley alignment and hose routing should be checked (drive-belt pulleys must run parallel. Bent drive-belt pulleys must be replaced).

   3. Power-steering pump brackets should be checked for damage. (They may be straightened, but if heavily damaged or torn they should be replaced.)

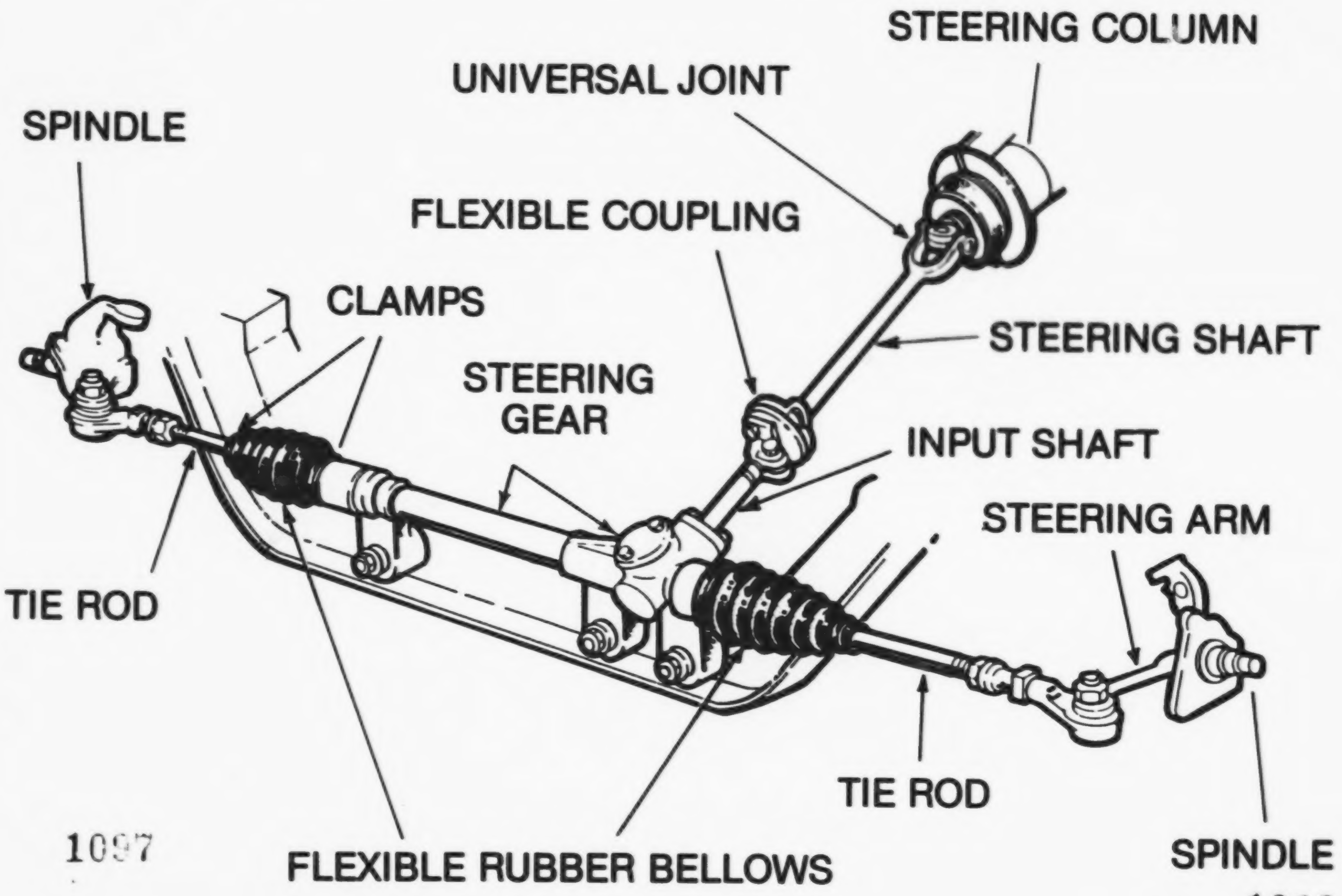
   4. Power steering hoses are carefully routed to prevent contact with engine parts. Original routings of hoses should be maintained, including location of attaching clips.

5. Power steering hoses should NOT be spliced.
6. For replacing power-steering pumps, consult vehicle manufacturer's recommendations.
7. Check oil level and belt tension according to manufacturer's specifications.

Conventional Steering Systems


STEERING COLUMN
STEERING GEAR
PITMAN ARM
IDLER ARM
STEERING ARM (2)
CENTER LINK
OR RELAY
LINK
TIE RODS
STEERING SPINDLE
BOLT
STEERING KNUCKLE (2)

Rack and Pinion Steering Systems


STEERING COLUMN
UNIVERSAL JOINT
SPINDLE
FLEXIBLE COUPLING
CLAMPS
STEERING SHAFT
STEERING GEAR
INPUT SHAFT
STEERING ARM
TIE ROD
TIE ROD
FLEXIBLE RUBBER BELLOWS
SPINDLE

TM 2

I-FRAME - 69

UNIT II

JOB SHEET #1, LESSON ONE

SERVICING POWER STEERING SYSTEMS

Equipment:

Hand tools
Replacement parts, if needed
Safety glasses

Procedure:

		Evaluation: 3	2	1	N
1.	Check pulley alignment and drive belts with visual inspection and replace if necessary.	___	___	___	___
2.	Check steering pump brackets for damage and straighten or replace as necessary.	___	___	___	___
3.	Check routing of power-steering hoses and make sure there is not contact with engine parts. If needed, reroute hoses.	___	___	___	___
4.	Check pump operation. Replace pump, if needed following service manual procedure.	___	___	___	___
5.	Check oil level and belt tension according to manufacturer's specifications.	___	___	___	___
	Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency W10 "Service power-steering system.")

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT II: STEERING SYSTEMS AND FRONT DRIVE TRAINS

LESSON TWO: FRONT DRIVE TRAIN REMOVAL

I. **Terms and definitions**

A. Constant velocity joint (CVJ) – A ball-and-socket type universal joint used on the drive axles in front drive trains. Also known as a Cardan universal joint. It allows up to a 40-degree operating angle.

B. Cradle assembly – A crossmember-type steel component which holds the drive train and suspension together as one unit on some unitized vehicles.

C. Drive train – The combination of engine, transaxle, drive axles and wheels which power the vehicle.

D. Transaxle – The transmission and differential unit on transverse front engine, front-wheel-drive vehicles.

E. Transverse mounted engine – An engine mounted so that it is perpendicular to the vehicle centerline.

II. **Front drive trains and mountings**

A. Changes in car design, because of 1974 federal standards, caused the production of lighter vehicles.

B. The standard front-engine, rear-wheel-drive vehicle was gradually replaced by the front-engine, front-wheel-drive vehicle because fewer and lighter component parts can be used.

C. Change in designs to lighten unibody vehicle and overall need to reduce weight of vehicles led to new power train mounting in which:

1. A transverse-mounted engine reduced the size of the engine compartment, along with the MacPherson strut suspension, which takes up less room, has fewer parts, and is lighter than the SLA.

2. The power train and suspension are more interconnected.

3. The power train and suspension are bolted directly to the unibody. This is the most important element of suspension design on unibody vehicles – if body panels are bent, the suspension may be misaligned and can only be properly aligned by straightening the damaged body panels.

D. The transverse-mounted front drive train with MacPherson strut suspension made the removal of mechanical components more necessary in vehicle damage repair because:

1. The suspension and drive train will not be in proper alignment if the body is not in proper alignment.

2. Vehicle damage is sometimes more quickly and more accurately repaired if mechanical components are removed.

3. Having the drive train and suspension interconnected and bolted to body panels made removing drive train and suspension a practical operation. (The time saved in repairing body damage when the mechanical components are removed is greater than the time spent removing and replacing the mechanical components.)

E. Front drive train mountings

1. There are two ways in which the front drive train maybe attached to the vehicle:

    a. Bolted directly to structural body panels

    b. With the lower attachment points bolted to a cradle or crossmember assembly, which is then bolted to structural body panels. (The upper mountings are still bolted to the strut tower and to body panels.)

2. In both above cases the alignment of structural body panels is essential to the correct alignment of suspension and power train components.

3. In addition to the overall alignment of the mechanical components, control linkages must be in proper position, including:

    a. Throttle linkages.

    b. Transmission linkages.

    c. Drive shaft linkages (drive shaft angles).

4. Motor mounts must prevent motor vibration from being transferred to the vehicle, and are generally special designs which must be kept in factory alignment. If the mounting fasteners are lost or damaged, they must be replaced with identical mounting fasteners.

5. In removing and replacing front drive trains, all components must meet factory specifications.

III. Principles of front drive train removal and replacement

A. Front drive trains are installed in one piece at the factory, being lifted up into the car.

B. Normally, all front drive trains will be removed by lowering the drive train out of the vehicle.

C. Service manuals contain specific cautions which must be followed when disassembling or rebuilding drive train components.

D. When replaced, fasteners must be torqued to their original specifications.

E. General sequence of work

(NOTE: Vehicle service manual procedure must always be consulted and followed.)

1. Start at top of engine compartment, disconnecting and marking (when necessary) all lines, hoses, wires, cables and linkages. Some components may have to be removed.
2. Raise vehicle and properly support.
3. From underside of vehicle, remove brake calipers, exhaust pipe and other components, as necessary.
4. Support drive train on proper jack, remove bolts holding suspension and engine, then lower drive train down and out of vehicle.

UNIT II

JOB SHEET #1, LESSON TWO

REMOVE AND REPLACE FRONT DRIVE TRAIN

(NOTE: Due to the wide variety of drive train configurations, your instructor will demonstrate exact procedure and equipment to the extent instructor determines necessary for safe completion of job.)

Equipment:

Vehicle with transverse-mounted front drive train
Proper supporting system for vehicle
Proper supporting system for drive train assembly
General hand and power tools
Personal Safety Equipment

Safety:

1. Follow all safety procedures related to raising and supporting vehicle. Refer to Module 3, "Panel repairs."
2. Follow all safety procedures related to the use of hand and power tools.
3. Follow all safety procedures related to handling cooling systems, air conditioning systems, power steering and power brake systems, fuel systems, and electrical systems.

Procedure:	**Evaluation:** 3	2	1	N
1. Disconnect all components which can be disconnected from top of engine compartment and label connections.	___	___	___	___
2. Raise and support vehicle.	___	___	___	___
3. Disconnect all underside connections except those directly connecting drive train or suspension to body.	___	___	___	___
4. Properly support drive train and vehicle for drive train removal.	___	___	___	___
5. Disconnect mounting bolts fastening suspension and drive train to body.	___	___	___	___
6. Remove suspension and drive train.	___	___	___	___

Steps of procedure for re-installation	Evaluation: 3	2	1	N
1. Properly support vehicle for re-installation.	___	___	___	___
2. Properly position suspension and drive train for re-installation.	___	___	___	___
3. Reconnect mounting bolts fastening suspension and drive train to body.	___	___	___	___
4. Reconnect all underside connections other than those connected in step 3.	___	___	___	___
5. Remove supports and lower vehicle.	___	___	___	___
6. Reconnect all components which can be reconnected from top of engine compartment.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency W5 "Remove and reinstall front drive train.")

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT II: STEERING SYSTEMS AND FRONT DRIVE TRAINS

UNIT II TEST

I. Use the correct letter from the diagram to identify the terms.

_____1. Idler arm and bracket

_____2. Pitman arm

_____3. Steering gear

_____4. Steering column

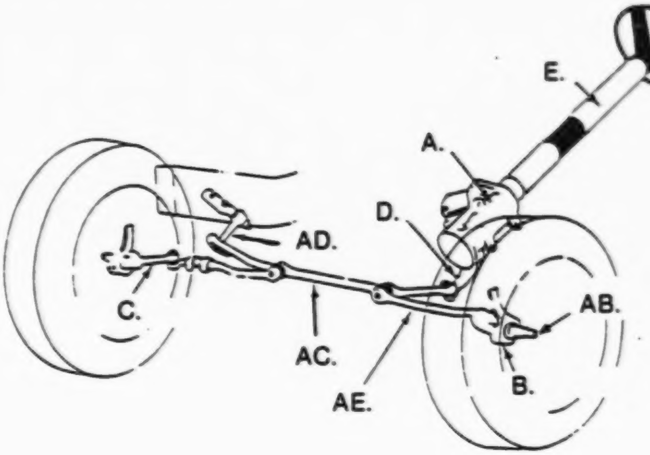
_____5. Steering arm

_____6. Center link

_____7. Tie rod

_____8. Steering knuckle

_____9. Steering spindle bolt



II. Use the correct letter from the diagram to identify the terms.

_____10. Steering spindle

_____11. Rubber bellows

_____12. Steering gear

_____13. Flexible coupling

_____14. Universal joint

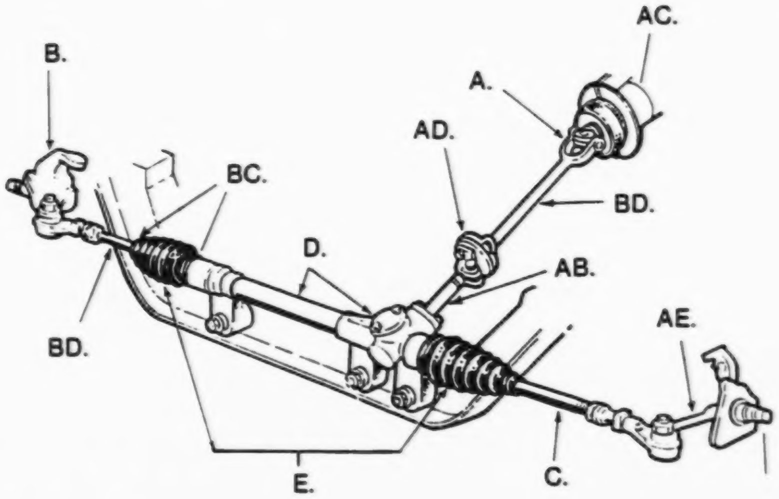
_____15. Steering column

_____16. Steering shaft

_____17. Input shaft

_____18. Steering arm

_____19. Tie rod



(NOTE: Completion of this unit test is the evaluation for Competency W7, "Identify steering systems." Of the 19 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, and _____ correct or below, student should retake this test.)

ANSWERS TO UNIT II TEST

1. AD
2. D
3. A
4. E
5. C
6. AC
7. AE
8. B
9. AB

10. B
11. E
12. D
13. AD
14. A
15. AC
16. BD
17. AB
18. AE
19. C

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT III: SUSPENSION GEOMETRY

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify the angles of suspension geometry, identify causes of uneven tire wear and analyze suspension problems. Mastery will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Identify Terms and definitions (Competencies W8 and W9, Part I of Unit III test)

II. Identify suspension geometry as it impacts auto body (Competencies W8 and W9, Part I of Unit III test)

III. Identify angles of front end geometry (Competencies W8 and W9, Part I of Unit III test)

IV. Identify four-wheel alignment procedures (Competency W8, Part I of Unit III test)

V. Identify causes of uneven tire wear (Competency W12, Part II of Unit III test)

VI. Identify suspension quick checks (Competency W9, Part I of Unit III test)

VII. Demonstrate the ability to:

  a. Perform suspension quick-checks (Competency W9, Job Sheet #1)

  b. Perform 4-wheel alignment (Competency W8, Job Sheet #2)

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT III: SUSPENSION GEOMETRY

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contests of this unit

C. Notes to the instructor

D. References

E. Lesson plans

   1. Lesson 1: Steering and suspension geometry

      a. Information outline

      b. Transparency masters

         TM#1: Camber
         TM#2: Caster
         TM#3: Toe-in
         TM#4: Toe-out on turns
         TM#5: Steering axis inclination

      c. Handouts

         HO#1: Abnormal tire wear patterns

      d. Job sheets

         JS#1: Perform suspension quick-checks
         JS#2: Perform four-wheel alignment

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. In evaluating Competency W1 "Perform four-wheel alignment," the vehicle should have some form of skew or rear-wheel offset. However, the competency could be evaluated by having the student accurately measure and diagnose an undamaged vehicle. (If they diagnose it as undamaged, they've diagnosed it correctly.)

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MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT III: SUSPENSION GEOMETRY

LESSON ONE: STEERING AND SUSPENSION GEOMETRY

I. **Terms and definitions**

A. Alignment -- The act of lining up suspension components to properly set camber, caster and toe.

B. Bump steer -- A change in toe causing the car to steer in one direction or the other during a sharp jounce or rebound.

C. Camber -- The tilt of the top of the tire from a vertical plane parallel with the centerline of the vehicle; when the tilt is outward at the top, the camber is positive.

D. Caster -- The tilting of the steering pivot points forward or backward. When the tilt is rearward at the top pivot point, the caster is positive.

E. Cornering wear -- Type of tire-tread wear caused by turning at excessive speeds or improper turning radius.

F. Front-end geometry -- The angular relationships among the front wheels, wheel-attaching parts, and car frame. Includes camber, caster, steering-axis inclination, toe, and turning radius.

G. Included angle -- Camber angle plus steering-axis inclination angle.

H. Kingpin inclination -- The pivot angle on older model cars which used a steel pin (kingpin) on which the steering knuckle pivoted (same as SAI).

I. Radial tire -- A tire in which the plies are placed radially, or perpendicular to the rim.

J. Radial-tire waddle (lateral force) -- A condition that makes a vehicle move from side-to-side when it is in motion at relatively low speeds (5 to 30 miles per hour). The tires must be replaced.

K. Roadability -- The steering and handling traits of a vehicle as it is being driven on the road.

L. Shimmy (Dynamic) -- Any rapid swinging back and forth of the suspension system. In wheel shimmy, for example, the front wheel turns in and out rapidly causing the front end of the car to waver, or shimmy.

M. Skew -- (Also known as dog tracking) A misalignment condition where the rear wheels are not perpendicular to the centerline of the body. The condition is also described by the thrust line of the rear wheels not being parallel with centerline of vehicle body.

N. Steering axis – The line extending through the upper and lower pivots of the steering knuckle. The steering knuckle, wheel and tire rotate around the steering axis when the steering wheel is turned. In a conventional SLA independent suspension, the steering axis passes through the upper and lower ball-joints. In a MacPherson strut suspension, the steering axis passes through the top pivot point of the strut and through the lower ball joint. The point at which the line of the steering axis meets the road surface is called the pivot point.

O. Steering-axis inclination (SAI) – The inward tilt of the steering axis from the vertical (also known as ball-joint inclination and kingpin inclination). On MacPherson-type suspensions, steering-axis inclination is also called the steering control angle. It is measured in degrees from the true vertical to a line extending through the upper and lower pivot points.

P. Steering kickback – Sharp and rapid movements of the steering wheel as the front wheels encounter obstructions in the road.

Q. Suspension quick-checks – Four measurements taken to reveal damage to MacPherson-strut-type suspension systems.

R. Trust line – A line perpendicular to the average axis of the two rear wheels. In a perfectly aligned vehicle the trust line is straight ahead. In a misaligned vehicle, the thrust line and the body centerline are not parallel and the condition is called skew (dog tracking).

S. Toe – The difference in distance between the front and rear of the tires at one end of the vehicle. If the tires at one end of the car are closer at the front than at the rear, they have toe-in. If the tires at one end of the car are closer at the rear than at the front, they have toe-out.

T. Torque steer – A condition sometimes found on front-wheel-drive vehicles where the vehicle tends to steer in one direction during acceleration.

U. Turning radius – The difference between the angles each of the front wheels make with the car frame during turns, usually measured with the outside wheel turned 20 degrees. On a turn, the inner wheel turns (toes out) more to allow faster rotation. Also called toe-out-on-turns.

V. Wheel alignment – Adjusting or aligning the suspension and steering components to assure a vehicle's proper handling and optimum tire wear.

W. Wheel balancer – A device that checks a vehicle's wheel-and-tire assembly for balance. There are two types – static and dynamic.

II. **Suspension geometry and the auto body technician**

A. Front-end geometry is the angular relationship between the front wheels, wheel-attaching parts, and car frame. Includes camber, caster, steering-axis inclination, toe, and turning radius.

B. Suspension alignment on unibody vehicles includes the rear wheels as well as the front wheels, including the concepts of tracking and four-wheel alignment.

C. Suspension alignment has only recently become a key part of the modern bodyshop technician's skills because:

  1. In the past, suspension adjustments were made by specialists in that field.

  2. Modern unibody construction, including the use of rack-and-pinion steering and the MacPherson strut, have taken some responsibility for suspension work away from the specialist and into the body shop.

D. In modern unibody construction, the suspension components are bolted directly to structural body panels and most suspension adjustments have been eliminated. Therefore:

  1. If certain body panels are bent, the suspension will not be in proper alignment.

  2. If the suspension is not in proper alignment and suspension parts are not damaged, then it is the responsibility of the body shop to make alignment corrections by correcting the body structure.

E. Much responsibility for suspension alignment now rests with the body shop, and the body shop must know how to properly repair suspensions, because:

  1. Most unibody damage serious enough to damage structural panels will also cause misalignment of the suspension.

  2. The ride and handling characteristics are the first things noticed by the owner of a collision-repaired vehicle. If it looks new but drives poorly, the owner will bring the vehicle back to the shop.

F. Suspension geometry applies equally to all suspensions.

G. SLA-type vehicles still contain many adjustments and alignment specialists will still perform those alignments, but not so for most unibody vehicles.

H. Comparisons of suspension systems.

  1. SLA suspension

    a. More parts

    b. More sensitive

    c. More adjustments

  2. Strut suspension

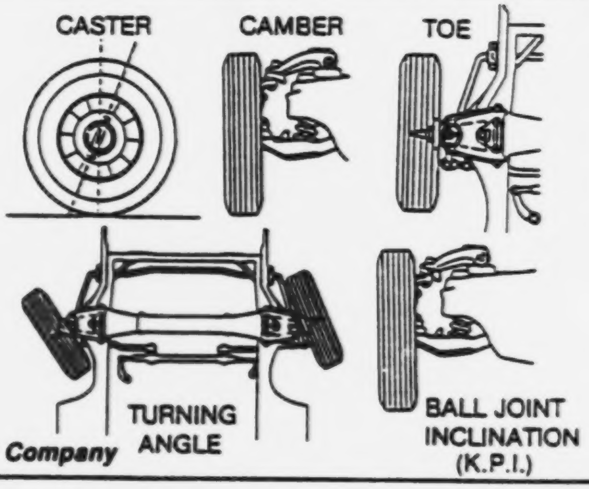
    a. Fewer parts

    b. Less wear

    c. Fewer adjustments

I. To understand suspensions, it is necessary for the body technician to understand the angles involved in suspension geometry: (FIG. 1-1)

FIG. 1-1



Courtesy of Ford Motor Company

K. The above angles are important because they must be maintained within narrow tolerances if a vehicle is to handle well, ride well and prevent rapid wear of tires.

L. Some of the angles for front suspension are adjustable on some vehicles and some are adjustable on all vehicles.

1. Toe is adjustable on all vehicles.
2. Camber is adjustable on most vehicles.
3. Caster is not adjustable on most unitized vehicles.
4. Turning radius is not adjustable on any vehicle.
5. Steering-axis inclination is not adjustable on any vehicle.

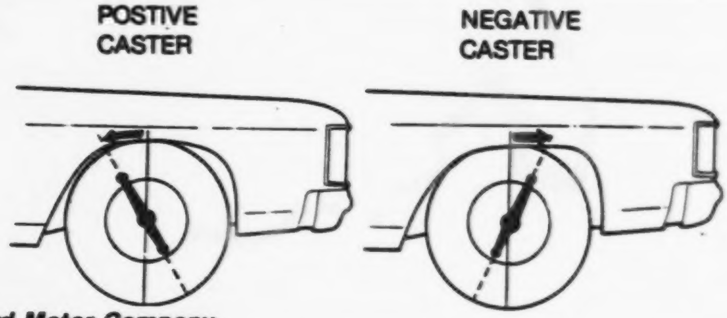
M. In order to have vehicles handle properly, they are designed and the suspension angles set so that they provide the best handling characteristics. Engineers do this taking into account that the angles change as the vehicle turns, accelerates, brakes or goes over bumps.

III. **The angles of front-end geometry**

(NOTE: Camber and toe are also angles of rear-wheel geometry, but except for toe, rear wheels are seldom adjustable and rear-wheel alignment is much less complex).

A. Caster (FIG. 1-2)

FIGURE 1-2



POSTIVE CASTER

NEGATIVE CASTER

Courtesy of Ford Motor Company

1. Caster is the angle between a true vertical line running through the center of the wheel and the center line passing through the steering axis.

2. Caster is viewed from the side and is measured in degrees.

3. Caster is measured by recording the difference in the camber readings with the wheel turned in at the front 20 degrees, through center, to 20 degrees out at the front. A vehicle may have positive, zero or negative caster.

4. If the angle between the true vertical line and the steering axis leans rearward, caster is positive. If the angle leans forward, it is negative. If there is no angle, then caster is zero.

5. Purpose of caster angle

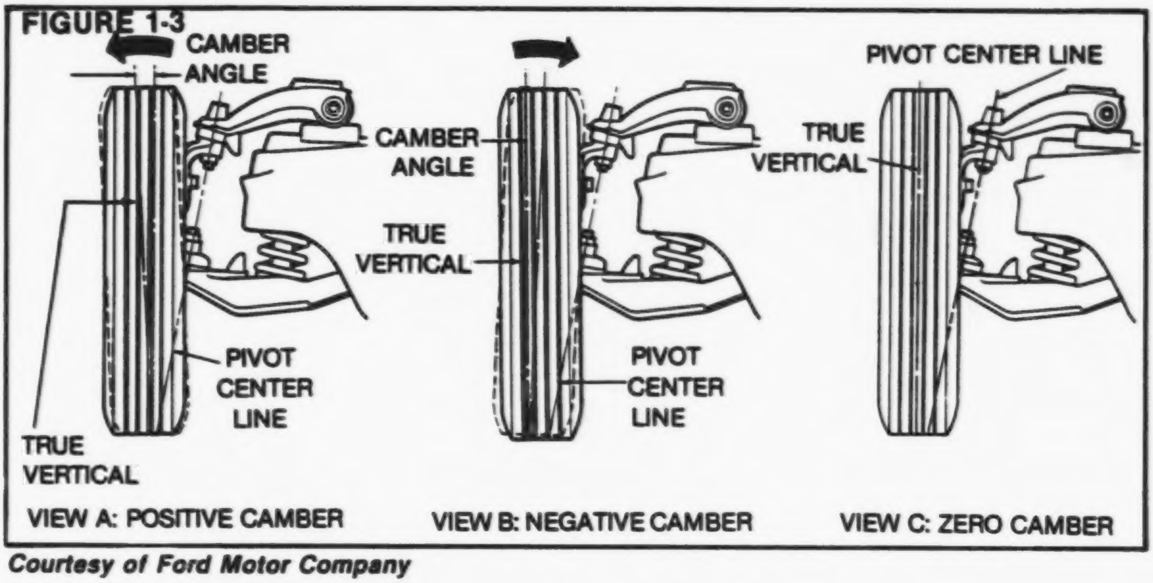
   a. Caster is a factor in a vehicle's tendency to follow a straight course.

   b. Caster is a factor in the tendency of the wheels to resume a straight-ahead position after they have been turned.

   c. Caster is a factor in the effort needed to turn the wheels from straight-ahead position.

B. Camber (FIG. 1-3)

FIGURE 1-3


CAMBER
ANGLE
CAMBER
ANGLE
PIVOT CENTER LINE
TRUE
VERTICAL
TRUE
VERTICAL
PIVOT
CENTER
LINE
PIVOT
CENTER
LINE
TRUE
VERTICAL
VIEW A: POSITIVE CAMBER
VIEW B: NEGATIVE CAMBER
VIEW C: ZERO CAMBER

Courtesy of Ford Motor Company

1. Camber is the angle formed by a vertical line passing through the center of the tire tread and a true vertical line from the center of the tire tread where it meets the road surface

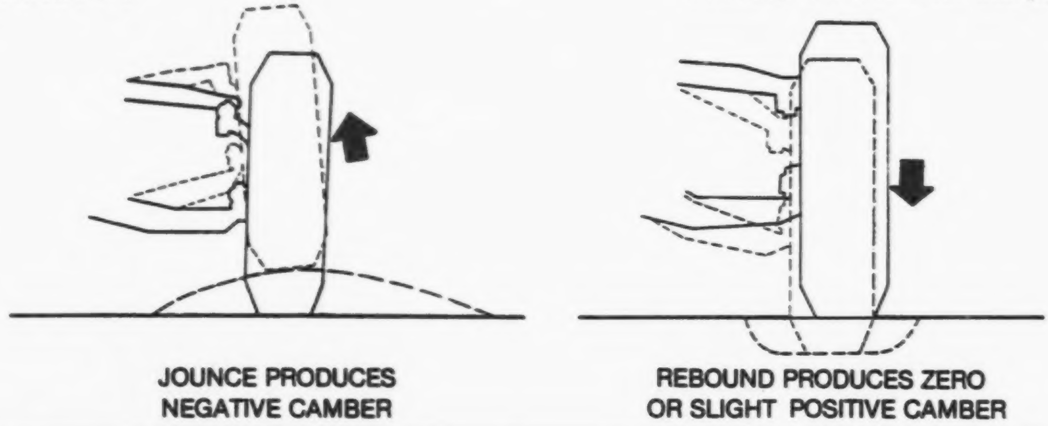
2. If the angle formed is toward the inside of the tire then the camber is negative. If the angle formed is toward the outside of the tire, then the camber is positive. With no angle camber is zero.

3. Camber is viewed from the front and is measured in degrees.

4. The camber angle changes as the load on suspension changes, as with jounce and rebound. (FIG. 1-4)

FIGURE 1-4

Courtesy of Ford Motor Company


JOUNCE PRODUCES
NEGATIVE CAMBER
REBOUND PRODUCES ZERO
OR SLIGHT POSITIVE CAMBER

5. The purpose of camber

   a. Camber is a factor in the vehicle's tendency to follow a straight course.

b. Camber is a factor in tire wear.

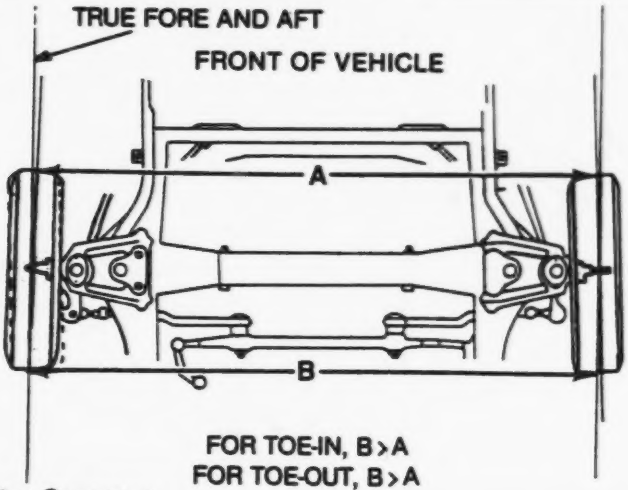
c. Camber is a factor in the tires maintaining proper contact with road surface.

d. Camber provides for a pivot point that will give maximum ease and control of steering.

e. Camber provides for vehicle weight to be carried properly on wheel-bearing surfaces.

C. Toe (FIG. 1-5)

FIGURE 1-5



Courtesy of Ford Motor Company

1. Toe is the difference in distance between the centers of the rear edges of tires at the same end of the vehicle and the distance between the centers of the front edges of the same tires. It may also be thought of as the angle between the true centerline of the vehicle and the centerline of the tires.

2. Toe is viewed from the top of the car looking down and is measured in inches or millimeters.

3. If the distance between the rear edges of the tires is greater than the distance between the front edges of the tires, then the condition is called "toe-in." If the front distance is greater than the rear distance, the condition is called "toe-out."

4. The purpose of toe

   a. Tires produce a rolling resistance as the treads revolve over a surface. This force tends to push the wheels outward and braking generates a similar force. For these reasons, most front-engine, rear-wheel-drive vehicles are set with "toe-in."

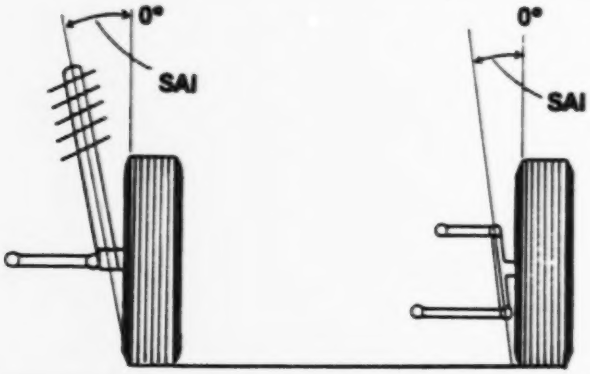
b. The driving forces produced on front-wheel-drive cars tend to counteract rolling resistance and force the tires inward at the front and top. Therefore, most front-wheel-drive vehicles are set with "toe-out."

c. Toe is a factor in tire wear, causing scuff or abrasive wear.

d. Toe is a factor in steering wander.

D. Steering-axis inclination (SAI) (FIG. 1-6)

FIGURE 1-6



1. SAI is determined by the line running through the center top-suspension pivot point and the bottom-suspension pivot point. For SLA suspension, this is the line between the upper and lower ball joints. For MacPherson-strut-type suspensions this is the line between the pivot point on the strut tower and the lower ball joint.

2. SAI is the angle between the line running through the pivot points and a true vertical line.

3. SAI is viewed from the front of the car and is measured in degrees.

4. SAI angles were designed into vehicles because the point at which the line defining SAI meets the ground is the point at which the wheel will most freely make a turn. The SAI angle is set so that the point at which it intersects the ground will be near the tread contact area. This angle also projects the vehicle's weight beneath the wheel.

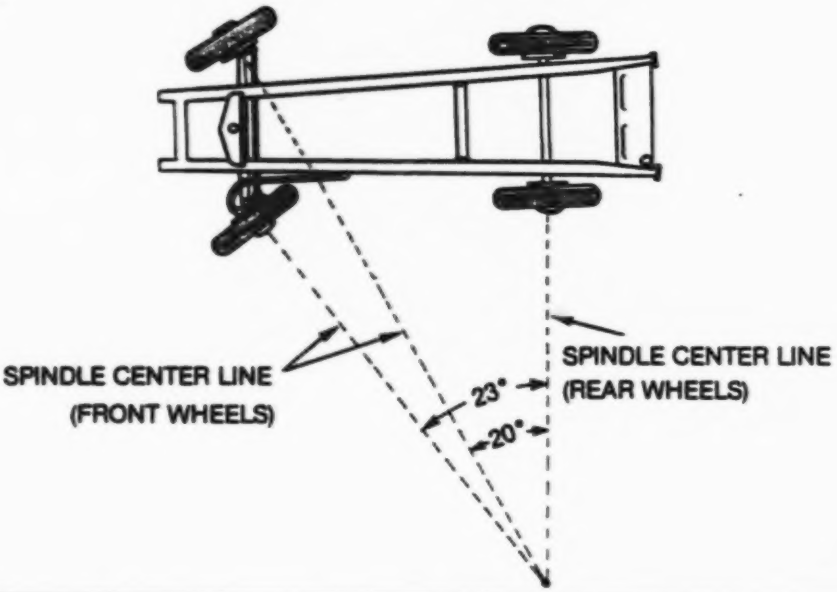
5. SAI influences the wheel's tendency to stay on a straight course and return to a straight-ahead position after turns by neutralizing the weight of the vehicle.

6. SAI influences tire wear.

7. SAI reduces the need for excessive camber and caster.

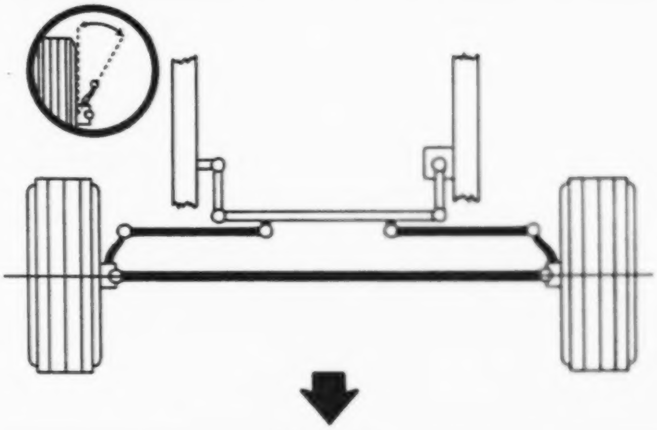
E. Turning angle (Toe-out on turns) (FIG. 1-7)

FIGURE 1-7


SPINDLE CENTER LINE
(FRONT WHEELS)
23°
20°
SPINDLE CENTER LINE
(REAR WHEELS)

1. The turning angle is the result of the configuration of suspension parts engineered into the vehicle and is not a separate adjustment. As in the figure above, the angle of the steering arms has been designed to allow each wheel to follow its own turning arc without slipping. (FIG. 1-8)

FIGURE 1-8



2. For purposes of uniformity in specifications, an outer- or inner-wheel turning angle of 20 degrees has been established as a base measurement.

3. Turning angle is the angle of the outer wheel when the inner wheel is turned at 20 degrees.

4. Turning angle is viewed from the top of the vehicle looking down and is measured in degrees.

5. Purpose of turning angle

    a. To make an efficient turn, all the wheels of the vehicle must turn about a common center point and each wheel must be perpendicular to the radius of the turn.

    b. When the wheels turn, they independently pivot at different distances from the center point.

    c. Because the inside wheel is forward of the outside wheel on a turn, it must turn at a sharper angle than the outside wheel to be perpendicular to the radius of the turn.

    d. This difference in the angles is a result of the configuration of the steering system and is not adjustable.

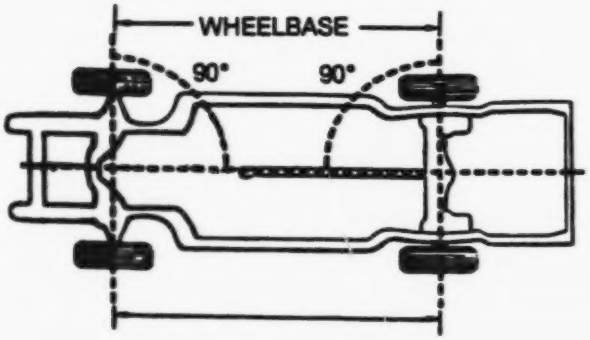
IV. Four-wheel alignment

A. Rectangle concept

1. The proper relationship between rear and front wheels can be thought of as a rectangle, with the four wheels at the four corners of the rectangle in such a way that:

    a. There is a 90-degree angle between the axles and the vehicle centerline. (FIG. 1-9)

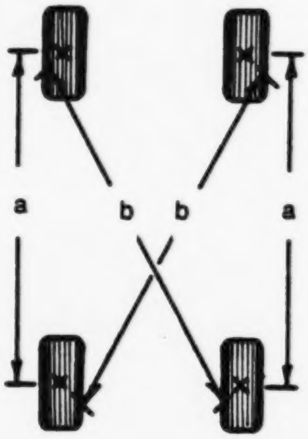
FIG. 1-9



    b. The distance between the front and rear wheels is the same on both sides of the vehicle. (FIG. 1-10)

    c. The distance between the diagonally opposite front and rear wheels is equal. (FIG. 1-10)

Fig. 1-10



2. In order for a vehicle to handle properly, the four wheels must form a rectangle, as defined above.

3. In assessing body or suspension damage, or in checking the accuracy of repairs, four-wheel alignment should be checked.

B. Thrust line (rear-wheel tracking line)

1. In measuring four-wheel alignment, the thrust line must be established.

2. The thrust line is the line defined by the average of the two angles of the rear wheels, as they point forward, with the line located on the centerline of the theoretical or actual axle between the two rear wheels.

3. On vehicles with no toe on rear tires, such as vehicles with solid rear-axle housings, the thrust line will be parallel to the center line of each wheel.

4. On vehicles with toe-in on the rear wheels, the thrust line is a line perpendicular to the average axis of the two rear wheels. Toe must be equal on both sides.

   (NOTE: Solid rear axles can still have toe-in if they are bent).

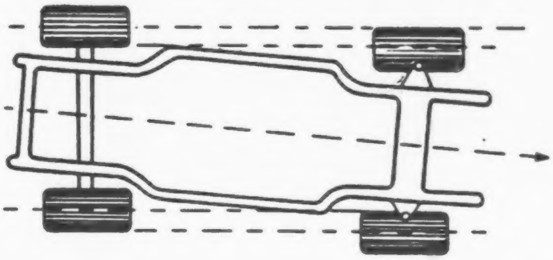
5. If the four wheels are in alignment, then the thrust line will be identical to the centerline of the vehicle and identical to the wheel center-line, which is the line between the two midpoints of the front and rear axles (or imaginary axles).

6. If the centerline and wheel centerline are equal but the thrust line is different, then the condition is known as "skew."

C. Four-wheel misalignment conditions

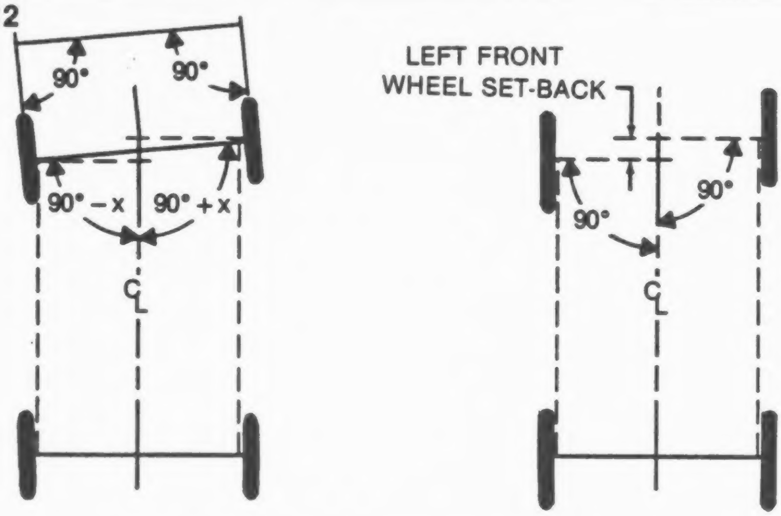
1. Skew (FIG. 1-11)

FIGURE 1-11



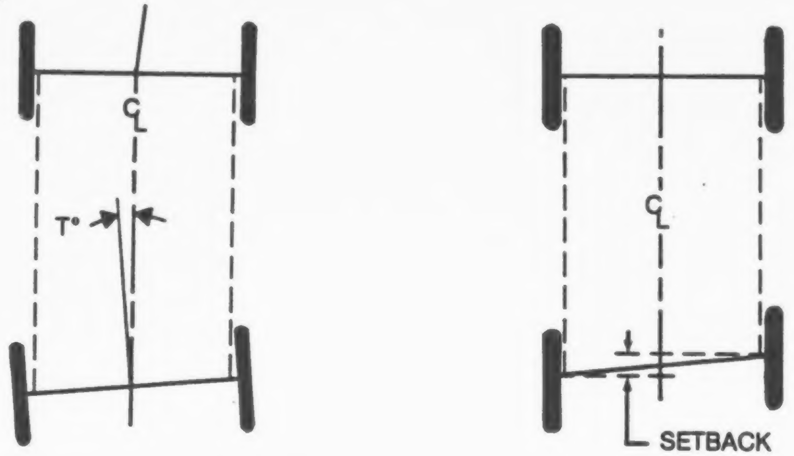
2. Front-wheel setback (FIG. 1-12)

FIGURE 1-12


90°
90°
90° − x
90° + x
CL
LEFT FRONT
WHEEL SET-BACK
90°
90°
CL

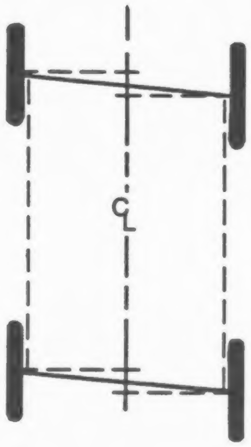
3. Rear-wheel setback (FIG. 1-13)

FIGURE 1-13



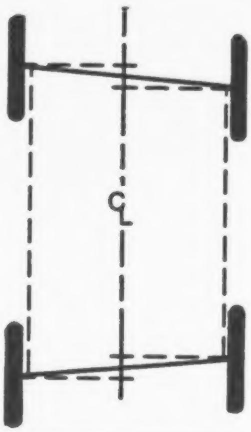
4. Parallelogram condition (front-and rear-wheel set-back on same side) (FIG. 1-14)

FIGURE 1-14



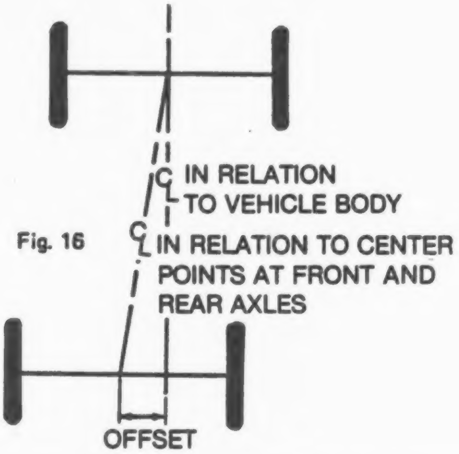
5. Trapezoid condition (Front- and rear-wheel set- back on opposite sides) (FIG. 1-15)

FIGURE 1-15



6. Rear-axle offset (FIG. 1-16)

FIGURE 1-16


CL IN RELATION
TO VEHICLE BODY
Fig. 16
CL IN RELATION TO CENTER
POINTS AT FRONT AND
REAR AXLES
OFFSET

D. To perform four-wheel alignment

1. Establish centerline of vehicle.
2. Establish wheel centerline.
3. Establish thrust line.

4. Establish distances between wheels on same side, and diagonally opposite wheels.

5. Check angles and distances revealed.

(NOTE: Your instructor will demonstrate how to perform four-wheel alignment checks according to equipment available. Four-wheel alignment is a relatively new field.)

V. Causes of uneven tire wear (See Handout #1)

(NOTE: Tire-wear patterns can, in some cases, help the bodyshop technician diagnose suspension and steering problems).

A. Toe-in wear -- An abrasive tapered or feathered edge on the tread due to the tire dragging instead of rolling.

B. Camber wear -- One side of the tire tread wearing faster than the other because the tire runs at an angle to the road.

C. Underinflation wear -- Faster wear on the outside edges of the tread.

D. Overinflation wear -- Faster wear on center of tread.

E. Cornering wear -- A diagonal abrasive wear on the outside edge of the tread caused by the tire skidding and tending to roll while cornering at excessive speeds.

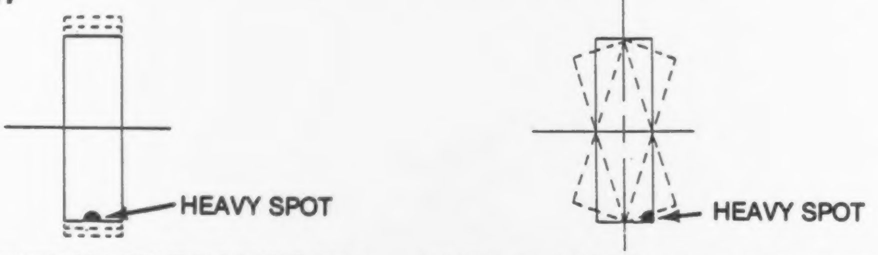
F. Multi-problem wear -- Occurs on vehicles that are driven mostly at highway speed without the recommended tire rotation, proper wheel balance, proper alignment, or from the vehicle having loose or worn suspension parts. Examples: Bald spot, cup, or scallop.

G. Additional problems are caused by tires being out of balance, or losing their proper shape.

1. Tire tramp -- Caused by a heavy spot on the tire, or out-of-round condition of the tire/wheel assembly. Can be identified with a wheel balancer. (FIG. 1-17)

2. Wheel shimmy -- Caused by a heavy spot on one side of the tire. Identified with a wheel balancer. (FIG. 1-17)

FIGURE 1-17

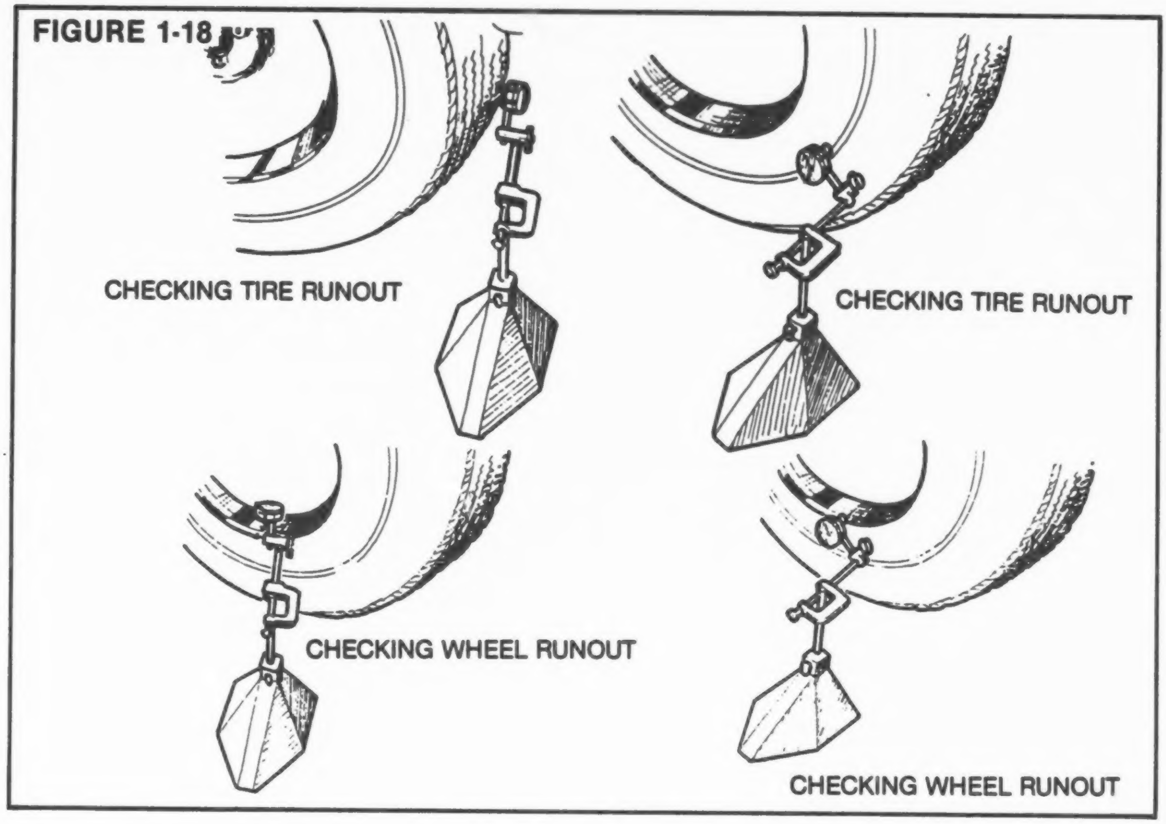


TIRE TRAMP (STATIC CONDITION) WHEEL SHIMMY (DYNAMIC CONDITION)

3. Tire runout -- The condition of the tire not being within tolerances of being perfectly round, or the sidewalls having high or low spots. Can be checked with a runout gauge. (FIG. 1-18)

4. Wheel runout -- The condition of the wheel rim not being within tolerances of round, or the side of the rim having high or low spots. Can be checked with a runout gauge. (FIG. 1-18)

FIGURE 1-18



VI. Performing suspension quick-checks

A. Suspension quick-checks are the most efficient means of the body shop technician to determine the condition of suspension and steering components in MacPherson-type front suspensions. This is the type of suspension body shop technicians must diagnose and analyze.

B. The analysis of handling problems in MacPherson strut-type suspensions is an attempt to identify the problem as being either the result of body misalignment or suspension component damage.

C. When a damaged vehicle comes to the shop with a steering problem, the first check is a visual inspection of the entire vehicle for obvious damage. Check for bent wheels and obvious cradle misalignment.

D. Four typical problems in handling can be diagnosed through suspension quick-checks.

1. Wander

    a. Commonly caused by suspension parts which are loose, worn or damaged, and/or binding of the "Thru-strut" bearing, or a bent strut rod.

    b. Can be diagnosed by inspecting the suspension system and performing quick-checks.

2. Front-end pull

    a. Often points to camber, caster and/or toe misalignment.

    b. Can be identified by camber/caster suspension quick-checks.

3. Poor return on turns

    a. Can point to binding or sticking condition in steering system, or misaligned caster angles.

    b. Caster angle check can reveal both conditions.

4. High steering effort

    a. Can point to binding or sticking condition in steering system, or excessive positive caster angles.

    b. Visual inspection and caster angle check can reveal both conditions.

E. Quick-checks are performed in this sequence:

1. Jounce-rebound toe-in.

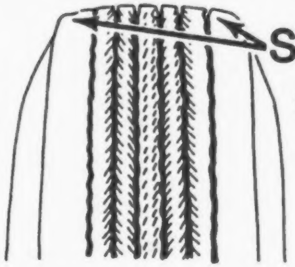
2. Cornering turning angle check.

3. Camber check for forward/rearward strut damage.

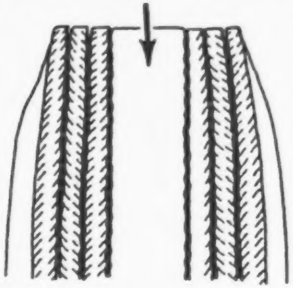
4. Camber check for inboard/outboard strut damage.

F. Quick-checks are easily performed with a minimum of equipment, as indicated in the job sheet.

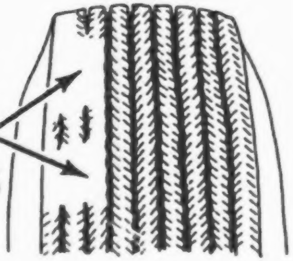
Abnormal Tire Tread Wear Patterns


SHOULDERS
OF TREAD
WORN

UNDER-INFLATION

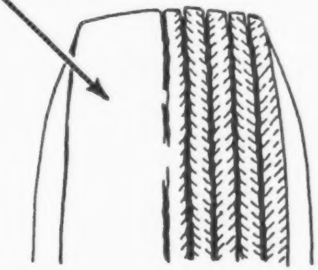

CENTER OF TREAD WORN

OVER-INFLATION

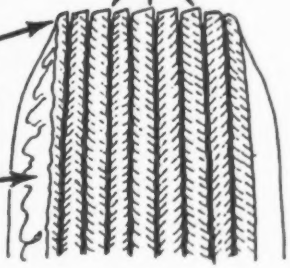

IRREGULAR
DEPRESSIONS

MULTI-PROBLEM

HO 1


ONE SIDE OF
TREAD WORN

CAMBER WEAR
CORNERING WEAR


FINS
SHOULDER OF
TREAD WORN
AND SCUFFED
ROUGH
SURFACE

TOE-IN WEAR

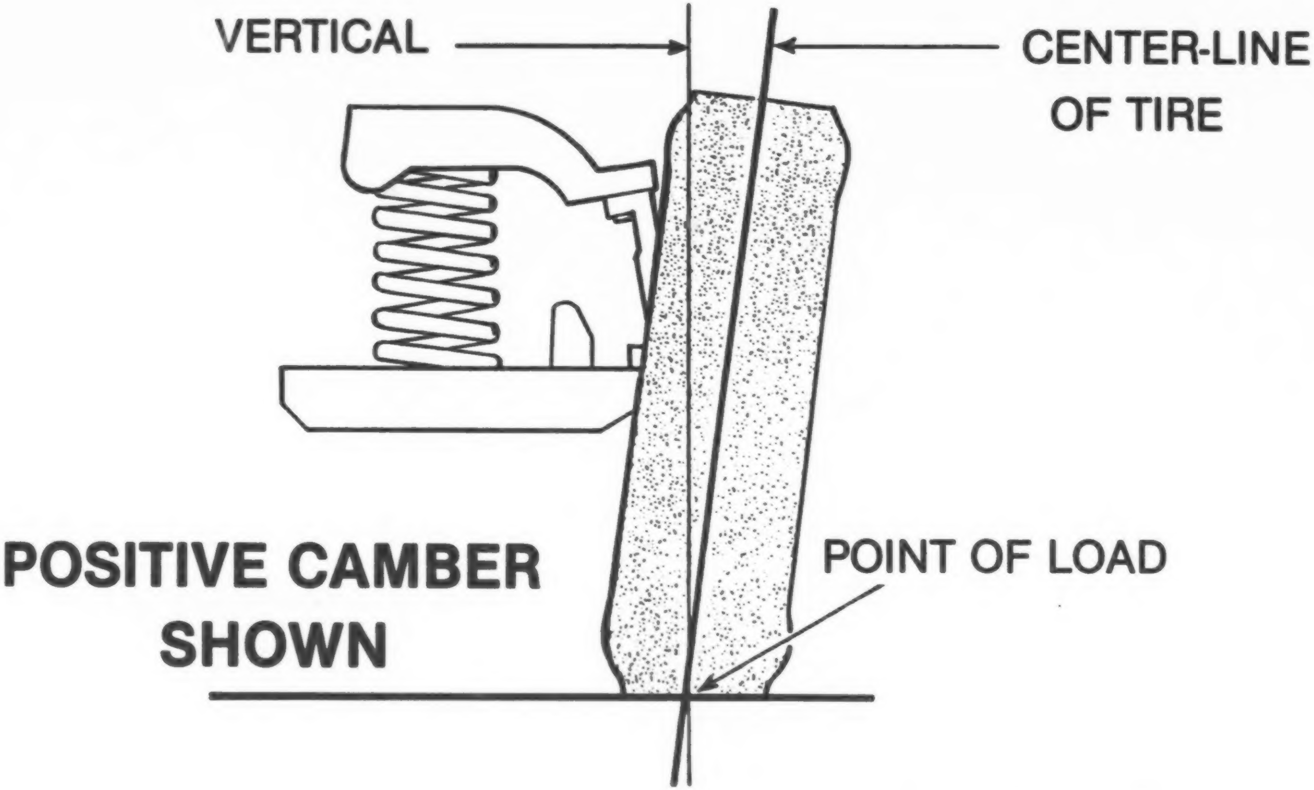
S-FRAME - 53

1127

1128

I-FRAME - 105

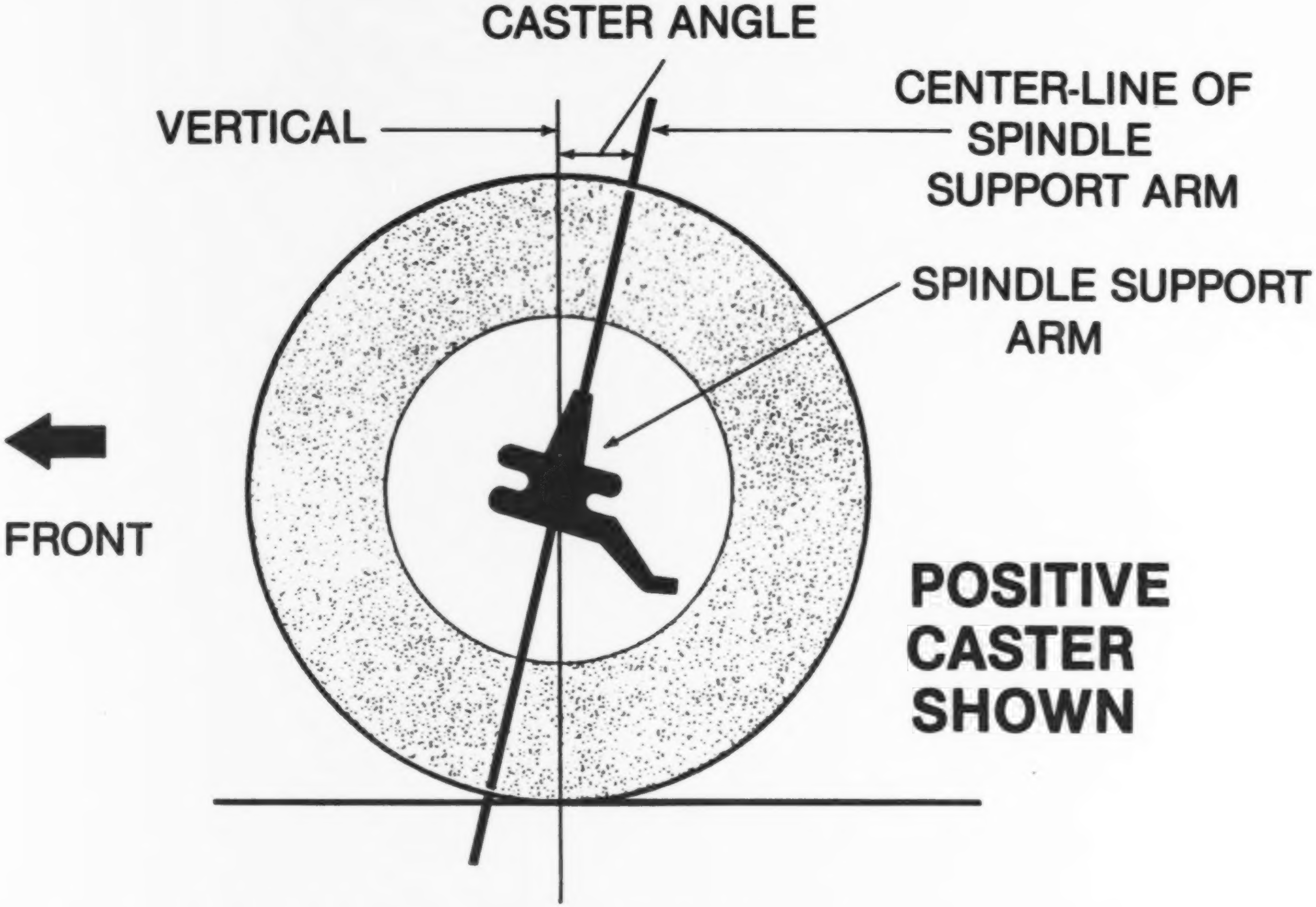
Camber


VERTICAL
CENTER-LINE OF TIRE
POSITIVE CAMBER SHOWN
POINT OF LOAD

THE OUTWARD OR INWARD TILT OF THE WHEEL AT THE TOP

TM 1

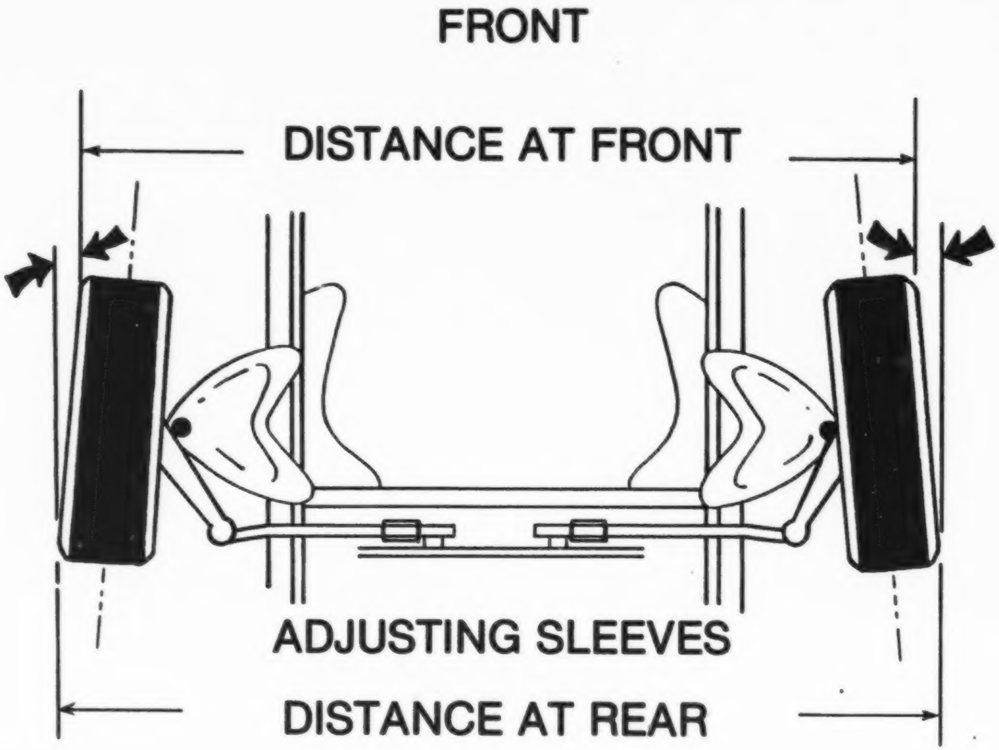
Caster


CASTER ANGLE
VERTICAL
CENTER-LINE OF SPINDLE SUPPORT ARM
SPINDLE SUPPORT ARM
FRONT
POSITIVE CASTER SHOWN

THE FORWARD OR REARWARD TILT OF THE SPINDLE SUPPORT ARM AT THE TOP

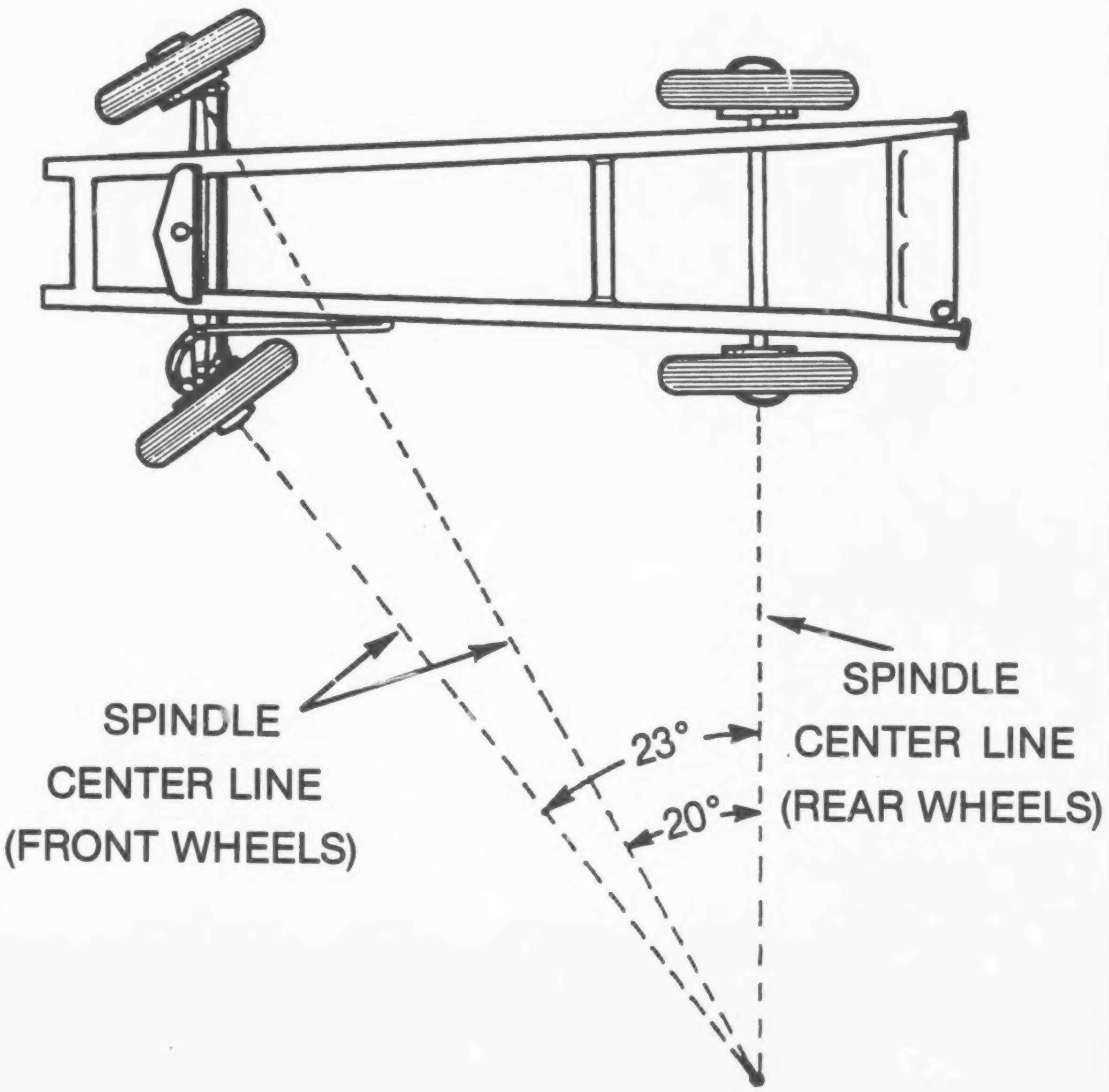
1131 1132

Toe-in

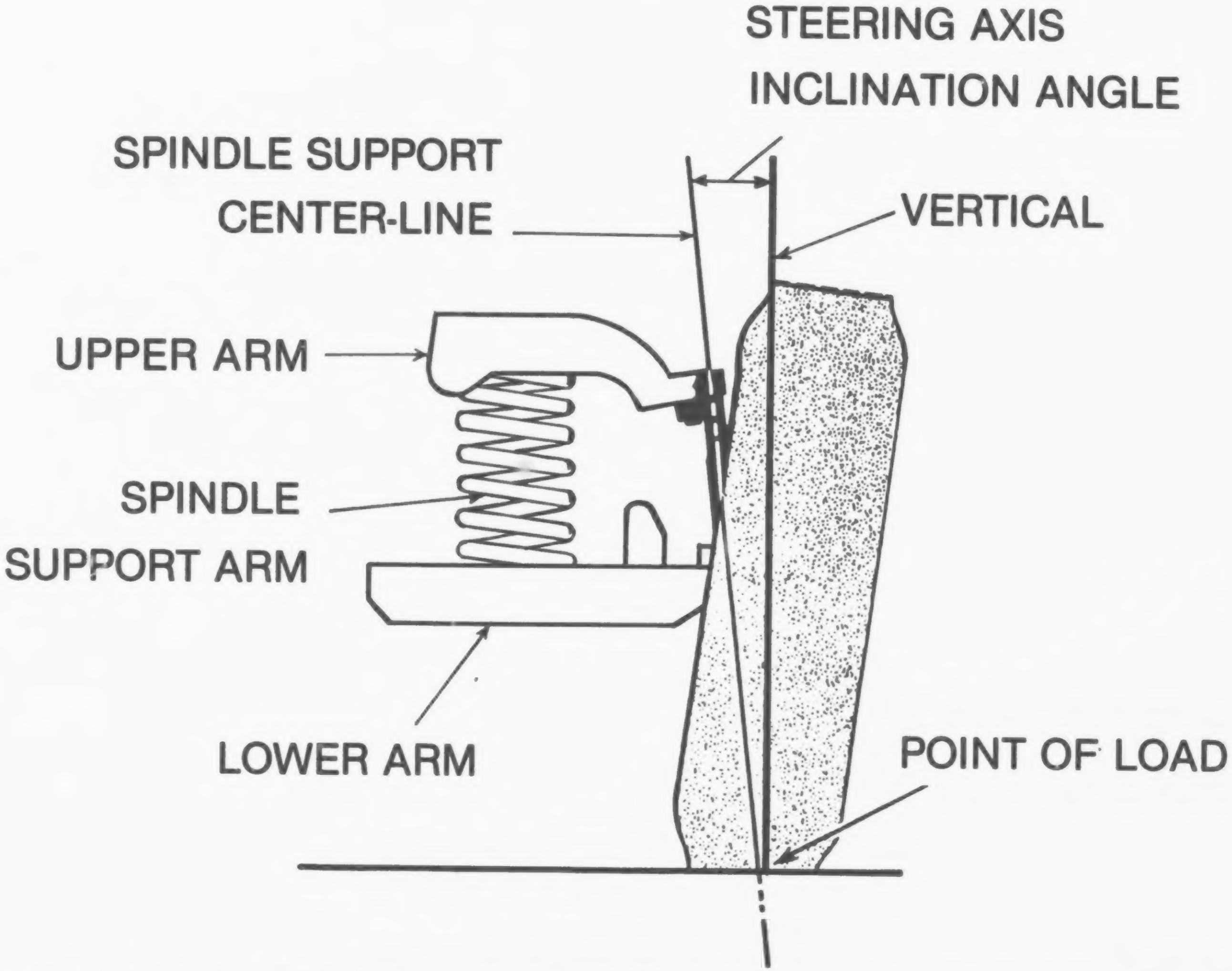

FRONT
DISTANCE AT FRONT
ADJUSTING SLEEVES
DISTANCE AT REAR

A SHORTER DISTANCE BETWEEN THE WHEELS AT THE FRONT THAN AT THE REAR

Toe-Out on Turns


SPINDLE
CENTER LINE
(FRONT WHEELS)
23°
20°
SPINDLE
CENTER LINE
(REAR WHEELS)

Steering Axis Inclination


STEERING AXIS
INCLINATION ANGLE
SPINDLE SUPPORT
CENTER-LINE
VERTICAL
UPPER ARM
SPINDLE
SUPPORT ARM
LOWER ARM
POINT OF LOAD

THE INWARD TILT OF THE SPINDLE SUPPORT ARM AT THE TOP.

TM 5

I-FRAME - 115

UNIT III

JOB SHEET #1, LESSON ONE

PERFORM SUSPENSION QUICK-CHECKS

Equipment

Vehicle with MacPherson strut-type suspension
Reference pointer for tire
Turntable protractor
Camber gauge or carpenter's protractor
Equipment for loading the suspension (often, having a person sit on the proper corner of the vehicle will work).

Procedure:	**Evaluation:** **3 2 1 N**
Jounce/rebound toe-in check for condition of steering gear or arm.	__ __ __ __

1. Mark reference mark on tire parallel to tread.
2. Place reference pointer near tire reference.
3. Jounce and rebound the suspension while observing the pointer and reference mark.

   (NOTE: If toe-in change is observed when either side is checked, steering gear or steering arm misalignment is likely.)

Turning angle check for condition of steering arms and spindle	__ __ __ __

1. Place vehicle front wheels on turntable protractor.
2. Turn left wheel outboard to 20 degrees and record cornering angle on right wheel.
3. Turn right wheel outboard to 20 degrees and record cornering angle of left wheel.

   (NOTE: If jounce/rebound toe-check shows a problem and cornering angles are within plus or minus 2 degrees, you have a misaligned steering gear)

Procedure: **Evaluation:**
3 2 1 N

Swing camber check, forward and rearward check to determine condition of the strut. ___ ___ ___ ___

1. Attach camber gauge or carpenter's protractor to to wheel spindle.

2. Swing wheel outboard to between 10-20 degrees and read the camber.

3. Swing wheel inboard the same amount as in step 2 and read the camber.

   (NOTE: If the strut is not bent forward or rearward, little difference will appear between the readings, usually less than 4 1/2 degrees. If it is bent, a larger difference will be noted, as much as 10 degrees).

Swing camber check, inboard and outboard check. ___ ___ ___ ___

(NOTE: Be sure to make both readings in the same place on the wheel).

1. Leave protractor or camber gauge in place from previous check and load suspension.

2. Read the camber angle and record.

3. Unload suspension and lift car slightly (can be done with jack or hands), record camber angle.

4. Compare readings (Should be equal plus or minus 1/2 degree).

   (NOTE: If strut is bent inboard or outboard, the readings will change significantly, as much as 4 to 5 degrees).

   Average of above evaluations* ___ ___ ___ ___

   (*This average is the evaluation for Competency W9 "Perform suspension quick checks.")

UNIT III

JOB SHEET # 2, LESSON ONE

PERFORM FOUR-WHEEL ALIGNMENT

Equipment

Vehicle
Tram/tracking gauge
Other alignment checking equipment, if available

Procedure:

(NOTE: Your instructor will demonstrate exact procedures according to equipment available in your shop).

	Evaluation: 3	2	1	N
1. Set vehicle on level surface with front wheels pointing straight ahead.	___	___	___	___
2. Establish vehicle thrust line.	___	___	___	___
3. Establish wheel center line.	___	___	___	___
4. Establish vehicle center line.	___	___	___	___
5. Measure distances between wheels on the same side, and diagonally opposite wheels.	___	___	___	___
6. Check angles and distances revealed and analyze alignment.	___	___	___	___
7. Align wheels according to damage revealed, following vehicle manufacturer's specifications.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average is the evaluation for Competency W8, "Perform four-wheel alignment.")

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT III: SUSPENSION GEOMETRY

UNIT III TEST

PART I—SUSPENSION GEOMETRY

I. Match the terms in the left column with the most closely associated definition or illustration in the right column.

1. The motion caused by a wheel going over a bump, compressing the spring.
2. The motion caused by a wheel going into a dip.
3. Any configuration of components which supports the weight of a vehicle on its axles and wheels
4. Turning radius
5. The act of lining up suspension components to properly set camber, caster and toe.
6. Camber
7. Caster
8. Skew
9. The line through the upper and lower pivots of the steering knuckle.
10. Steering axis inclination
11. A line perpendicular to the average axis of the two rear wheels.
12. Toe

A. Suspension system

B. Steering axis

C. Thrust line

D. Alignment

E. Jounce

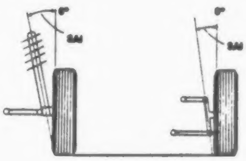
AB. Rebound

AC. Performance check

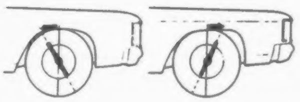
AD. Can be set on all vehicles

AE. Dog tracking

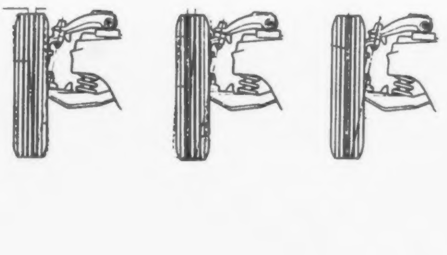
BC.



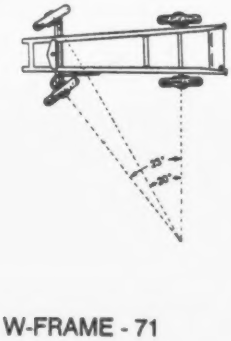
BD.



BE.



CD.



II. Mark on the answer sheet the best answer from the choices listed.

_____13. Most unibody damage serious enough to damage structural panels will also cause misalignment of the: (a) steering column, (b) ball joints, (c) suspension system, (d) constant velocity joints, (e) brake calipers.

_____14. Toe is adjustable on: (a) no vehicles, (b) some vehicles, (c) only SLA vehicles, (d) most vehicles, (e) all vehicles.

_____15. Camber is adjustable on: (a) no vehicles, (b) some vehicles, (c) only SLA vehicles, (d) most vehicles, (e) all vehicles.

_____16. Caster is adjustable on: (a) no vehicles, (b) some vehicles, (c) only SLA vehicles, (d) most vehicles, (e) all vehicles.

_____17. Turning radius is adjustable on: (a) no vehicles, (b) some vehicles, (c) only SLA vehicles, (d) most vehicles, (e) all vehicles.

_____18. Steering axis inclination is adjustable on: (a) no vehicles, (b) some vehicles, (c) only SLA vehicles, (d) most vehicles, (e) all vehicles.

_____19. Most rear-wheel-drive vehicles are set with toe-in on the front suspension because: (a) toe-in is easier to set, (b) toe-out makes turning harder, (c) toe-out cannot be set on the front, (d) tires produce rolling resistance, (e) driving forces counteract rolling resistance.

_____20. Most front-wheel-drive vehicles are set with toe-out in the front suspension because: (a) toe-out is easier to set, (b) toe-in makes turning harder, (c) toe-in cannot be set on the front, (d) tires produce rolling resistance, (e) driving forces counteract rolling resistance.

_____21. The angle that is a result of the configuration of suspension parts engineered into the vehicle and is not adjustable is the: (a) turning angle, (b) camber angle, (c) jounce angle, (d) included angle, (e) toe angle.

_____22. The method established to determine toe angle is to measure the angle of the outer wheel when the inner wheel is turned to: (a) 15 degrees, (b) 17 degrees, (c) 20 degrees, (d) 23 degrees, (e) 25 degrees.

_____23. If all four wheels on a vehicle are in alignment, then the thrust line will be identical to the (a) centerline, (b) wheel centerline, (c) distance between the front and rear wheels, (d) average distance between toe angles of the rear wheels, (e) both the centerline and the wheel centerline.

_____24. In a unibody vehicle with misaligned suspensions in which the suspension is not damaged, proper wheel alignment can only be achieved by (a) removing the power train, (b) aligning body panels, (c) making suspension adjustments, (d) performing four-wheel alignment, (e) a wheel alignment specialist.

(NOTE: Completion of Part I. of the unit test with a score of at least _________ % is necessary for the student to receive evaluations for Competencies W8 "Perform four-wheel alignment" and W9 "Perform suspension quick checks.")

PART II--EFFECTS OF TIRES ON STEERING

I. Use the correct letter from the list below to label the diagram for questions 33-37.

_____25. Camber and cornering wear

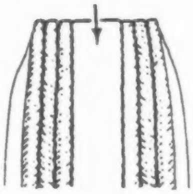
_____26. Toe-in wear

_____27. Over-inflation

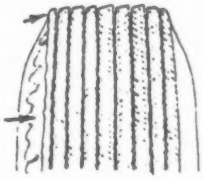
_____28. Under-inflation

_____29. Multi-problem

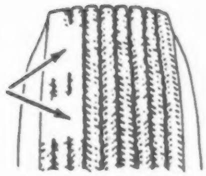
A.



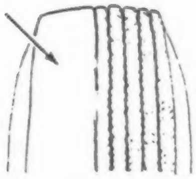
B.



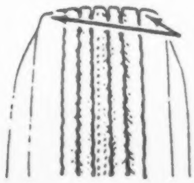
C.



D.



E.



(NOTE: Completion of this portion of the unit test is the evaluation for Competency W12 "Identify causes of uneven tire wear." Of the 5 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, the student should retake this portion of the test.)

ANSWERS TO UNIT III TEST

PART I.

1. E
2. AB
3. A
4. CD
5. D
6. BE
7. BD
8. AE
9. B
10. BC
11. C
12. AD

13. C
14. E
15. D
16. C
17. A
18. A
19. D
20. E
21. A
22. C
23. E
24. B

PART II.

25. D
26. B
27. AB
28. E
29. C

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT IV: VEHICLE CONSTRUCTION

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify vehicle construction characteristics. Mastery will be evidenced by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Match terms with their definitions or illustrations (Competencies X1 and X2, Part I, Unit IV test)

II. Identify conventional frame construction (Competencies X1 and X2, Part I, Unit IV test)

III. Identify unitized construction (Competencies X1 and X2, Part I, Unit IV test)

IV. Identify evolution of unibody frame (Competencies X1 and X2, Part I, Unit IV test)

V. Identify characteristics and uses of high-strength steel (Competency X5, Part II, Unit IV test)

VI. Identify the concepts of torque boxes, pinchwelds, and energy management (Competencies X1 and X2, Part I, Unit IV test)

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT IV: VEHICLE CONSTRUCTION

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. References

D. Lesson plans

  1. Lesson 1: Identifying vehicle frame construction

    a. Information outline

    b. Handouts

      HO#1: Parts of a typical frame
      HO#2: Unitized body

    c. Transparency masters

      TM#1: Crush zones

E. Unit test

F. Answers to unit test

REFERENCES USED IN WRITING THIS UNIT

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2. Chart Industries, Ltd. *Chart's Unibody Repair Program.* Chart Industries, Ltd. Pickering, Ontario. N.D.

3. Chrysler Corporation Technical Guide. *Working with High-Strength Steels.* Chrysler Corp. Center Line, MI. 1982.

4. Chrysler Motors. *Unibody Dimensions, Joints and Seams, All E Bodies.* Chrysler Training Programs. Chrysler Motors. Center Line, MI. 1986.

5. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

6. Duenk, Lester; Williams, Randolph; and Brooks, Clarence. *Auto Body Repair.* Second edition. Bennett Publishing Company. Peoria, IL. 1984.

7. General Motors Corporation. *1987 Body Service Manual (Buick, Oldsmobile, Cadillac).* General Motors Corporation. 1986.

8. Hilley, Robert. *Automotive Frame Repairer.* Curriculum & Instructional Materials Center. Oklahoma State Board of Vocational and Technical Education. Stillwater, OK. 1986.

9. Inter-Industry Conference on Auto Collision Repair. Unibody Auto Collision Repair Training Program. *Identification and Analysis of Collision Repair Damage on Unibody Vehicles.* D.I.A. Communications. Des Plains, IL. 1981.

10. Jensen, Eigil. *SMASH – The Modern Bodywork Repair Book.* Skandia-Trycheriet. Goteborg, Sweden. 1979.

11. Kansas Jack, Inc. *Body and Frame Alignment Instruction Manual.* McPherson, KS. N.D.

12. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

13. Scharff, Robert. *Motor Auto Body Repair.* Delmar Publishers, Inc. Albany, NY. 1988.

14. Toboldt, Bill. *Auto Body Repairing and Repainting.* The Goodheart-Willcox Co. Inc. South Holland, IL. 1982.

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT IV: VEHICLE CONSTRUCTION

LESSON 1: IDENTIFYING VEHICLE FRAME CONSTRUCTION

I. **Terms and definitions**

A. Alloy -- Any mixture of two metals.

B. Body -- For a vehicle, the assembly of structural and cosmetic panels, windows, doors and other parts that form the enclosures for the passenger compartment, engine compartment and luggage compartment.

C. Body panels -- Structural and cosmetic panels which are fastened together to form the vehicle body.

D. Chassis -- The configuration of steering and front- and rear-suspension systems, usually assumed to include everything except the body.

E. Energy management -- The process of designing vehicles in such a way that the impact energy of a collision is controlled and directed during impact.

F. Early unitized -- Class of vehicle styles utilizing initial attempts for unibody construction, in which a separate frame and body were welded together, or bolt-on stub frames were used.

G. Frame -- The assembly of steel structural parts and sections that supports the engine and body and is in turn supported by the suspension.

H. Frame-body construction -- Vehicle construction in which a separate frame supports the suspension and drive train, with the body bolted to the frame. Also known as a conventional frame.

I. HSS -- High-Strength Steel. Often used interchangeably with HSLA (high-strength/low alloy steel) in some reference materials.

J. Perimeter frame -- A frame design in which the base of the passenger compartment is surrounded by a frame. The body is bolted to the perimeter frame.

K. Pinchweld area of the rocker panel -- The factory weld that fuses the bottom flange of the outer rocker panel to the inner rocker panel. It is the strongest point for lifting, supporting and anchoring unibody vehicles.

L. Present-day unitized -- Vehicle construction including the use of high-strength steel and energy management design in which structural panels containing complex bends are welded together to form a design in which the body and frame are no longer separate. In modern construction, the structural integrity of the vehicle is compromised by the removal of any structural component.

(NOTE: Although the finished product of present-day unitized construction is a "one-piece" vehicle, the design is still composed of components that can be individually identified, and in many cases, individually repaired or replaced).

M. Torque boxes -- Energy management design used in both conventional frames and unibody construction, in which each corner of the passenger compartment is made with a twist-absorbing design.

N. Torque box area – Refers to the four corners of the passenger compartment regardless of whether the vehicle actually has torque boxes.

O. Unitized vehicle – Term may refer to any unitized construction. Other terms referring to unitized construction include unit body, unit coupe, unicoupe, and unibody.

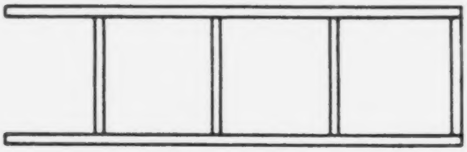
P. Unibody – May refer to any unitized construction, but is often refers to present-day construction, in which the frame and body can no longer be distinguished as separate units of construction.

(NOTE: The many terms for unibody construction are often used loosely. In this unit, "unibody" will refer to present-day construction).

II. Conventional frame construction

A. Early ladder frame (FIG. 1-1)

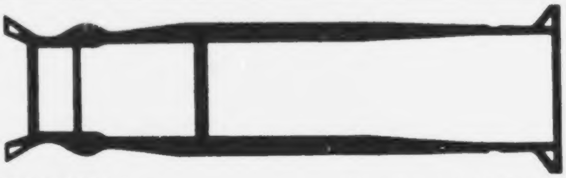
FIGURE 1-1



1. Was composed of flat steel beam siderails and channel iron crossmembers
2. Strength came from rigidity and massive frame.

B. Later ladder frame (FIG. 1-2)

FIGURE 1-2



LADDER FRAME

Courtesy of Blackhawk Automotive, Inc.

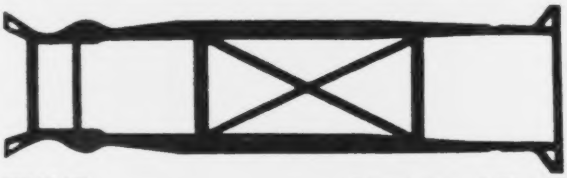
1. As automobile speeds increased due to better roads, the frame was designed to flex and the motor mounted lower in the chassis.
2. Flat beam siderails were replaced with I-beam or channel shape siderails and crossmembers.

C. Recent conventional frame designs

1. Complex frame designs added strength without weight to the lighter flexible frames.
2. Types of complex conventional frame designs

   a. "X" frame (FIG. 1-3)

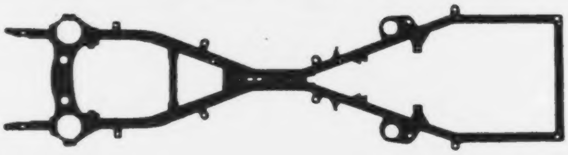
FIGURE 1-3



"X" FRAME *Courtesy of Blackhawk Automotive, Inc.*

   b. Hourglass frame (FIG. 1-4)

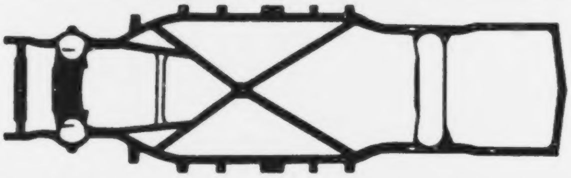
FIGURE 1-4



HOURGLASS *Courtesy of Blackhawk Automotive, Inc.*

   c. Combination frame (FIG. 1-5)

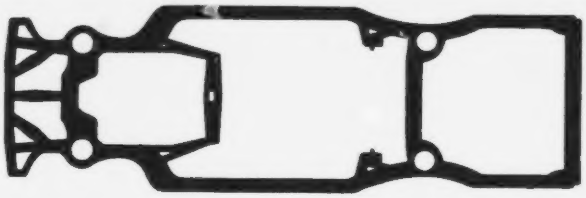
FIGURE 1-5



COMBINATION *Courtesy of Blackhawk Automotive, Inc.*

d. Perimeter frame (FIG. 1-6)

FIGURE 1-6

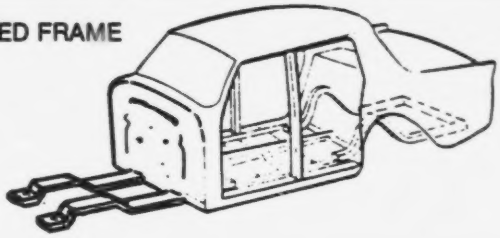


PERIMETER FRAME

III. **Unitized construction**

A. Early unitized construction (FIG. 1-7)

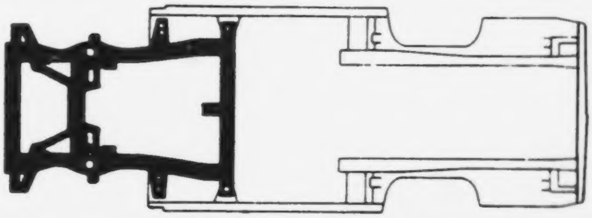
FIGURE 1-7 EARLY UNITIZED FRAME



1. The first unitized cars were built in the 1940s, with strength and rigidity built into the body through parts design and by welding parts together.
2. Partial frame rails were welded to the floor pan.

B. Bolt-on stub frame (FIG. 1-8)

FIGURE 1-8

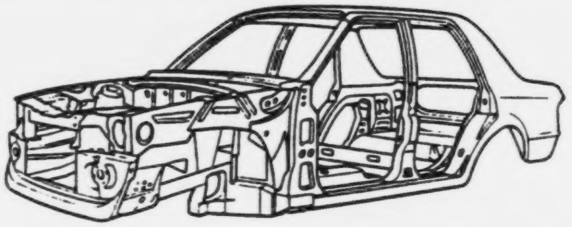


BOLT-ON STUB FRAME *Courtesy of Blackhawk Automotive, Inc.*

1. A combination of traditional frame and unitized body, with unitized body employed from cowl back and front section of a traditional frame bolted to unitized section.
2. Stub frame extends partially underneath passenger compartment and is bolted to unitized section at four locations.

C. Present-day unitized (FIG. 1-9)

FIGURE 1-9



UNITIZED *Courtesy of Blackhawk Automotive, Inc.*

1. Construction includes the use of high strength steel and energy management concepts in which structural panels containing complex bends are welded together to form a design in which the body and frame are no longer separate.
2. Three factors led to the gradual development of third-generation unibody construction, especially in the United States.
    a. 1974 federal laws placed strict fuel economy and emission control standards on automakers.
    b. Demands rose for higher safety standards.
    c. Consumers demanded fuel efficient cars as a result of gasoline price increases in 1970s.

IV. Evolution of U.S. cars by yearly design standards as demanded by 1974 laws

A. 1977 car models

1. Frame-body construction
2. 4500-pound fleet average
3. 18-gauge mild steel, no alloy
4. Independent front suspension with conventional steering system
5. Front engine, rear drive

B. 1978 car models

1. Unibody Ford Fox Chassis
2. 4200-pound fleet average
3. 22-gauge HSS
4. MacPherson-strut front suspension with rack-and-pinion steering system
5. Front engine, rear drive

C. 1980 car models

   1. Unibody construction

   2. 3600-pound fleet average

   3. 22-gauge HSS

   4. MacPherson-strut front suspension with rack-and-pinion steering system

   5. Transverse front engine, front drive

D. 1985 car models

   1. Unibody construction

   2. 2700-pound fleet average

   3. 24-gauge HSS

   4. MacPherson-strut front suspension with rack-and-pinion steering system

   5. Transverse-mounted front engine, front drive

V. Use of high-strength steels in unibody construction

A. Characteristics and uses of high-strength steels in present-day vehicles

   1. HSS was used to achieve weight reduction while maintaining vehicle strength.

   2. Unibodies achieve strength from high-strength steel and rigidity from complex bends.

   3. Term HSS is used to identify structural parts that have strength or other properties superior to the mild steels typically used to fabricate automotive structural parts. HSS generally is produced by adding exotic metal or metals to steel.

   4. With HSS, thinner gauges of steel may be used, which allows a reduction in vehicle weight without compromising strength.

   5. HSS requires special working considerations during repair procedures.

      a. Some HSS's are easily damaged by pulling forces during repair.

      b. Some are subject to strength loss and warping when welding.

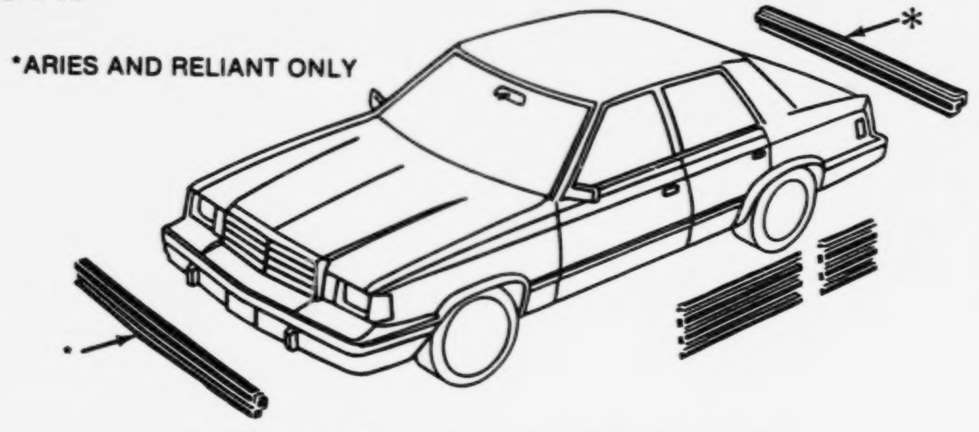
      c. Some are vulnerable to rust and corrosion.

      d. Ultra-high-strength steel cannot be repaired under any circumstances.

B. The three basic varieties of HSS

1. Martensitic or Ultra-High-Strength steels (FIG. 1-10)

FIGURE 1-10



MARTENSITIC OR ULTRA HIGH STRENGTH STEEL.
DO NOT HEAT - STRENGTH LOSS OCCURS.

Courtesy of Chrysler Motors

a. Have a special alloy-free composition.

b. Have a tensile strength almost ten times that of mild steel.

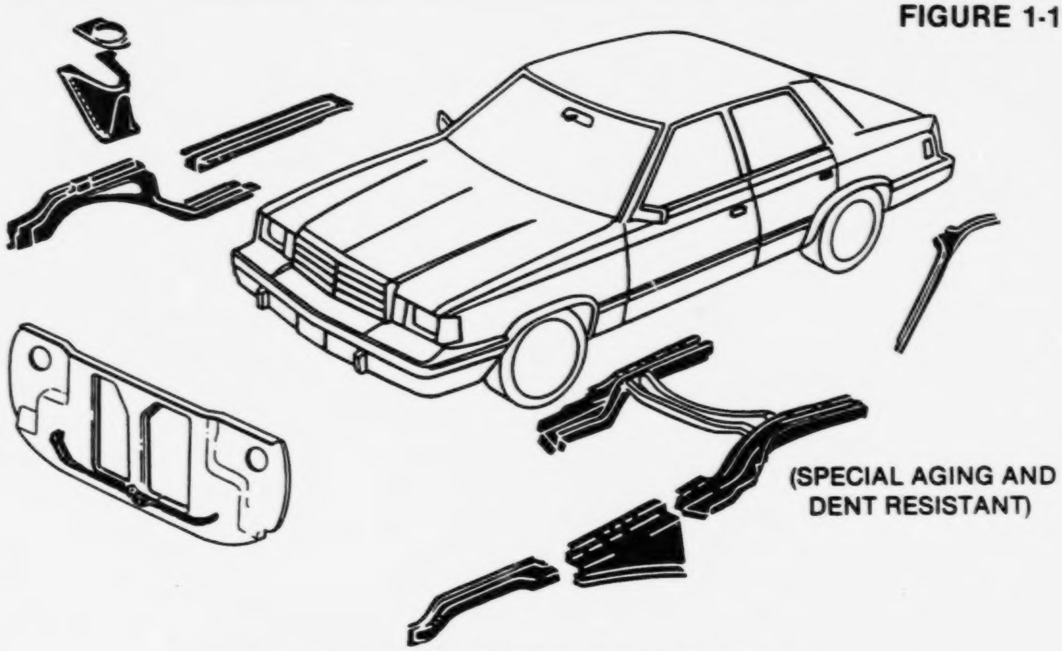
c. Cannot be heated without losing strength.

d. Are too hard to be straightened cold.

e. Must be replaced if damaged.

2. Special Aging or Dent-Resistant Steels (FIG. 1-11)

FIGURE 1-11



STRENGTH LOSS BEGINS IF HEATED TO 700° F.
AT 1000° F METAL REVERTS TO PLAIN LOW CARBON STEEL STRENGTH LEVELS.

Courtesy of Chrysler Motors

   a. Are resilient and can be returned to original shape.

   b. Are formed from steel that increases strength after formation.

   c. Can be heated, but only with care (check vehicle manufacturer's recommendations).

3. High-Strength, Low-Alloy (HSLA steels)

   a. Have special repair limitations – follow the manufacturer's recommendations.

   c. Often use coatings, such as galvanizing, which may produce noxious fumes when heated.

VI. Additional concepts in modern vehicle construction

A. Torque box areas (FIG. 1-12)

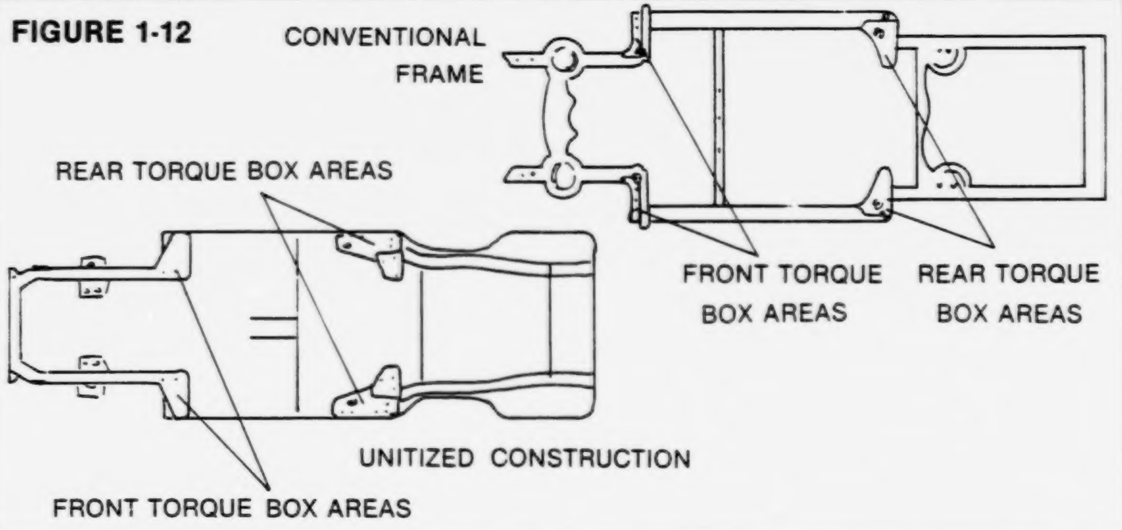


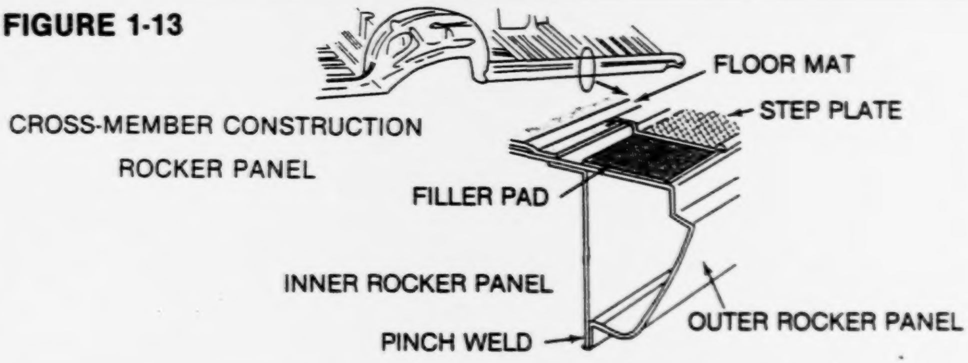
FIGURE 1-12

CONVENTIONAL FRAME
REAR TORQUE BOX AREAS
FRONT TORQUE BOX AREAS
REAR TORQUE BOX AREAS
UNITIZED CONSTRUCTION
FRONT TORQUE BOX AREAS

1. Are used in both frame-body and unitized designs.
2. Are designed to absorb twist (torque) forces, making for smoother riding in frame-body vehicles.
3. Are designed to absorb twisting forces in a collision, routing damage away from passenger compartment.
4. There are always four torque box areas per vehicle, at the corners of the passenger section.
5. Even if the vehicle does not have actual torque boxes, the four corners of the passenger compartment are referred to as "torque box areas."
6. Torque box areas are the strongest areas of vehicle for lifting and anchoring.

B. Pinchwelds (FIG. 1-13)

FIGURE 1-13


FLOOR MAT
STEP PLATE
CROSS-MEMBER CONSTRUCTION
ROCKER PANEL
FILLER PAD
INNER ROCKER PANEL
OUTER ROCKER PANEL
PINCH WELD

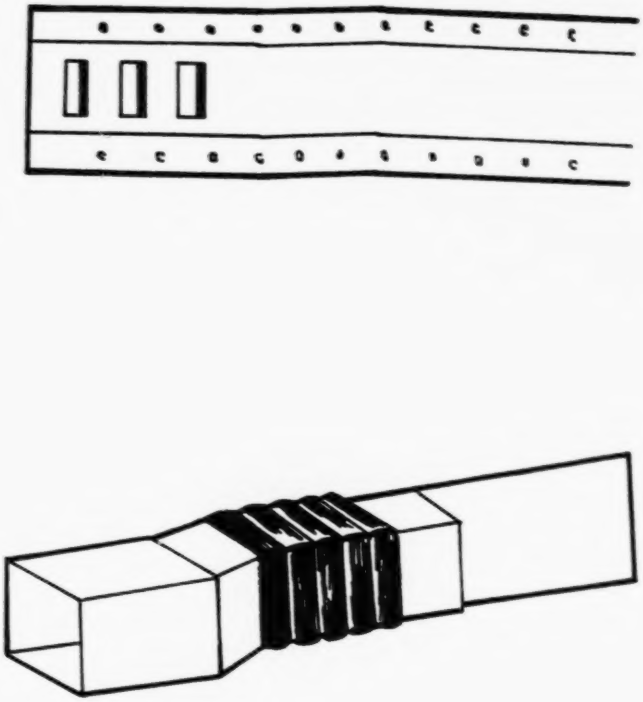
1. Are used in most unibody and some perimeter frame designs.
2. Refer to the weld fusing the bottom flange of the outer rocker panel to the inner rocker panel.
3. Are the strongest areas of unibody construction for anchoring and lifting.

C. Energy management

1. Using computer-aided design, engineers designing modern unibody vehicles are attempting to design cars that will better protect occupants during a collision.
2. Structural parts are each designed to handle a particular part of load of collision impact.

3. Some structural parts contain built-in areas designed to crush during a collision, known as crush zones or crumple zones. (FIG. 1-14)

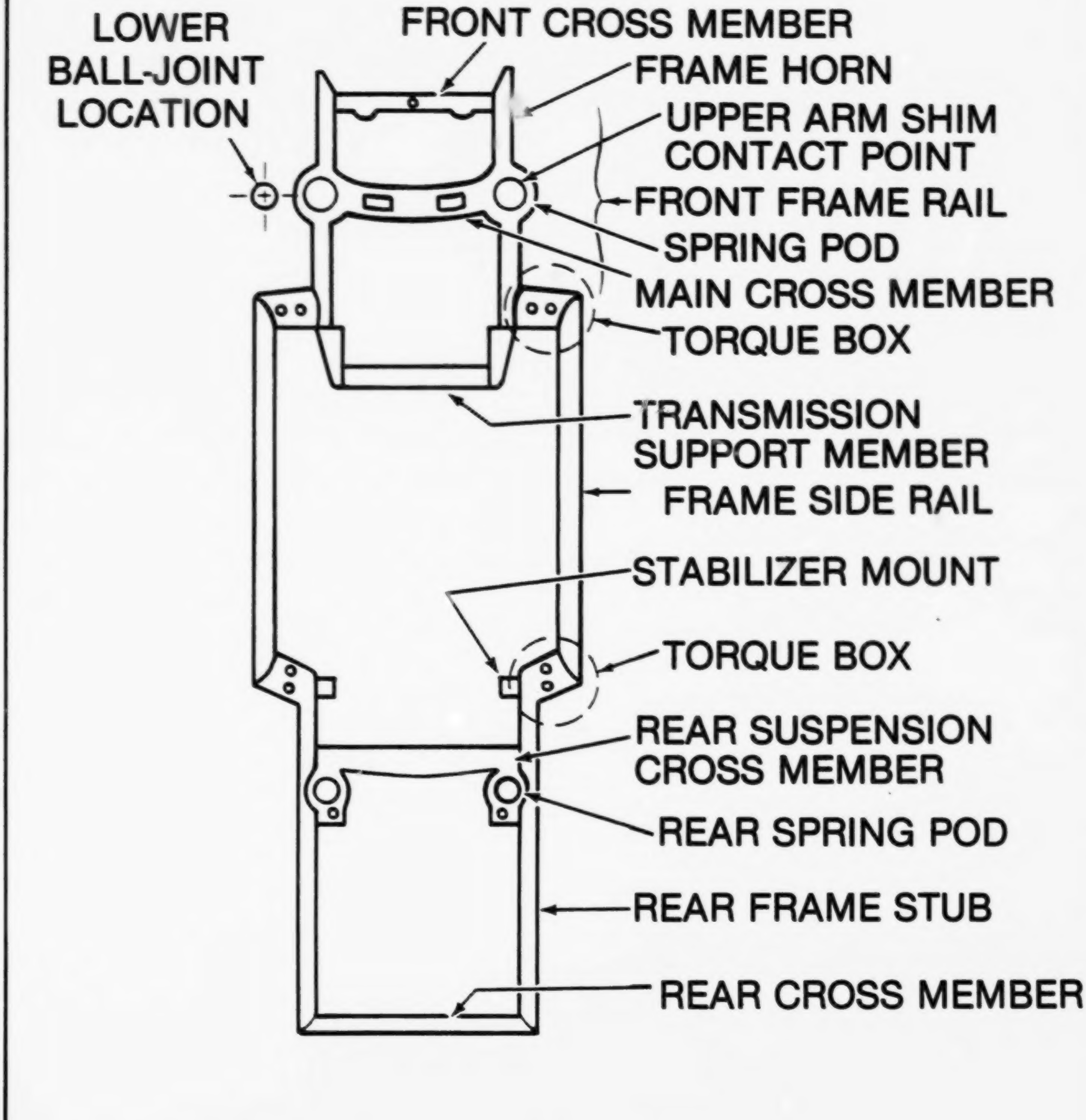
FIGURE 1-14



4. Front and rear compartments are designed to receive the brunt of collision damage.

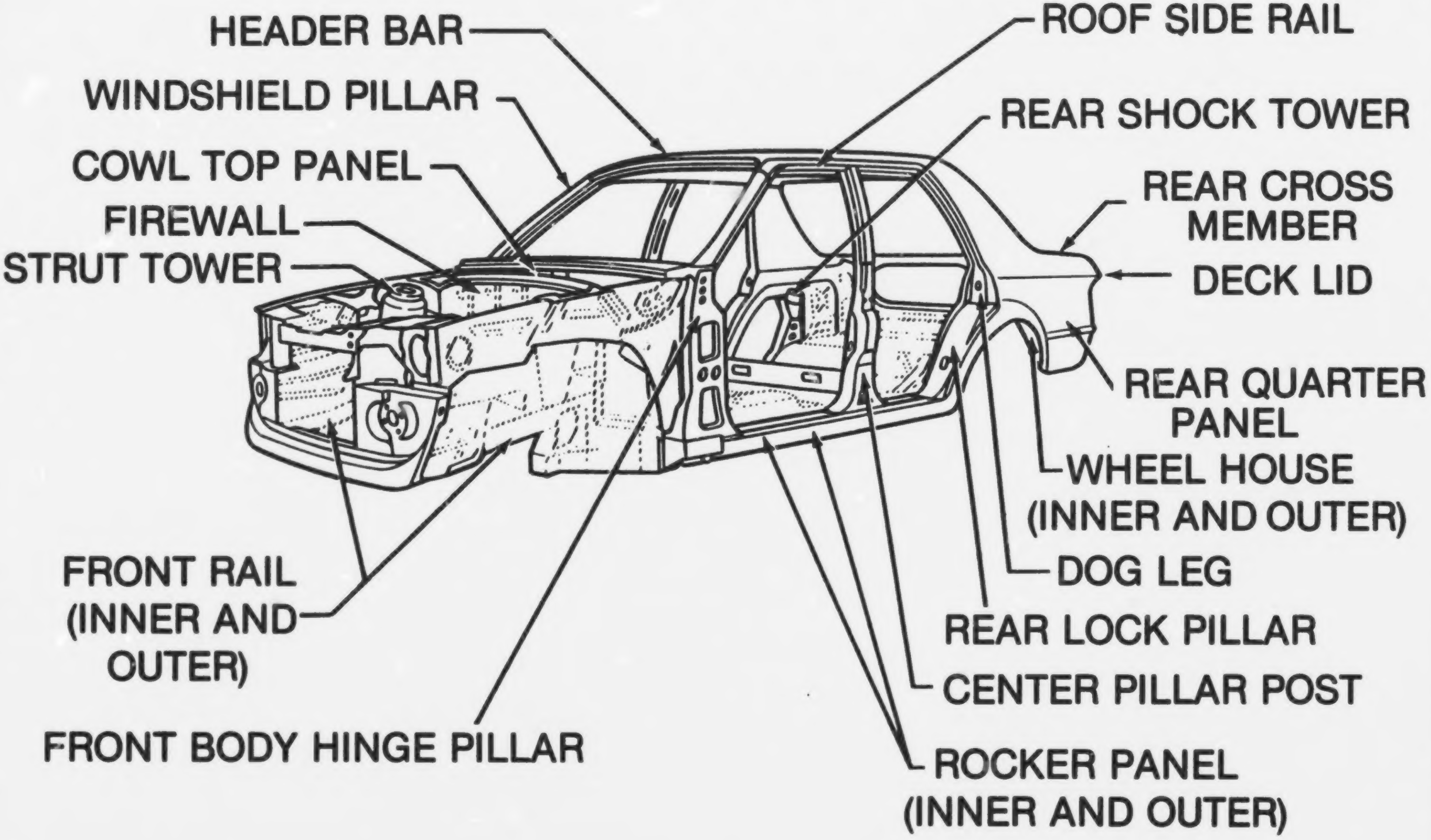
5. The energy of a collision impact is designed to be absorbed in an ever-widening area, by more and more structural components.

Parts of A Typical Frame


LOWER BALL-JOINT LOCATION
FRONT CROSS MEMBER
FRAME HORN
UPPER ARM SHIM CONTACT POINT
FRONT FRAME RAIL
SPRING POD
MAIN CROSS MEMBER
TORQUE BOX
TRANSMISSION SUPPORT MEMBER
FRAME SIDE RAIL
STABILIZER MOUNT
TORQUE BOX
REAR SUSPENSION CROSS MEMBER
REAR SPRING POD
REAR FRAME STUB
REAR CROSS MEMBER

Courtesy of Blackhawk Automotive, Inc.

Unitized Body


HEADER BAR
WINDSHIELD PILLAR
COWL TOP PANEL
FIREWALL
STRUT TOWER
FRONT RAIL (INNER AND OUTER)
FRONT BODY HINGE PILLAR
ROOF SIDE RAIL
REAR SHOCK TOWER
REAR CROSS MEMBER
DECK LID
REAR QUARTER PANEL
WHEEL HOUSE (INNER AND OUTER)
DOG LEG
REAR LOCK PILLAR
CENTER PILLAR POST
ROCKER PANEL (INNER AND OUTER)

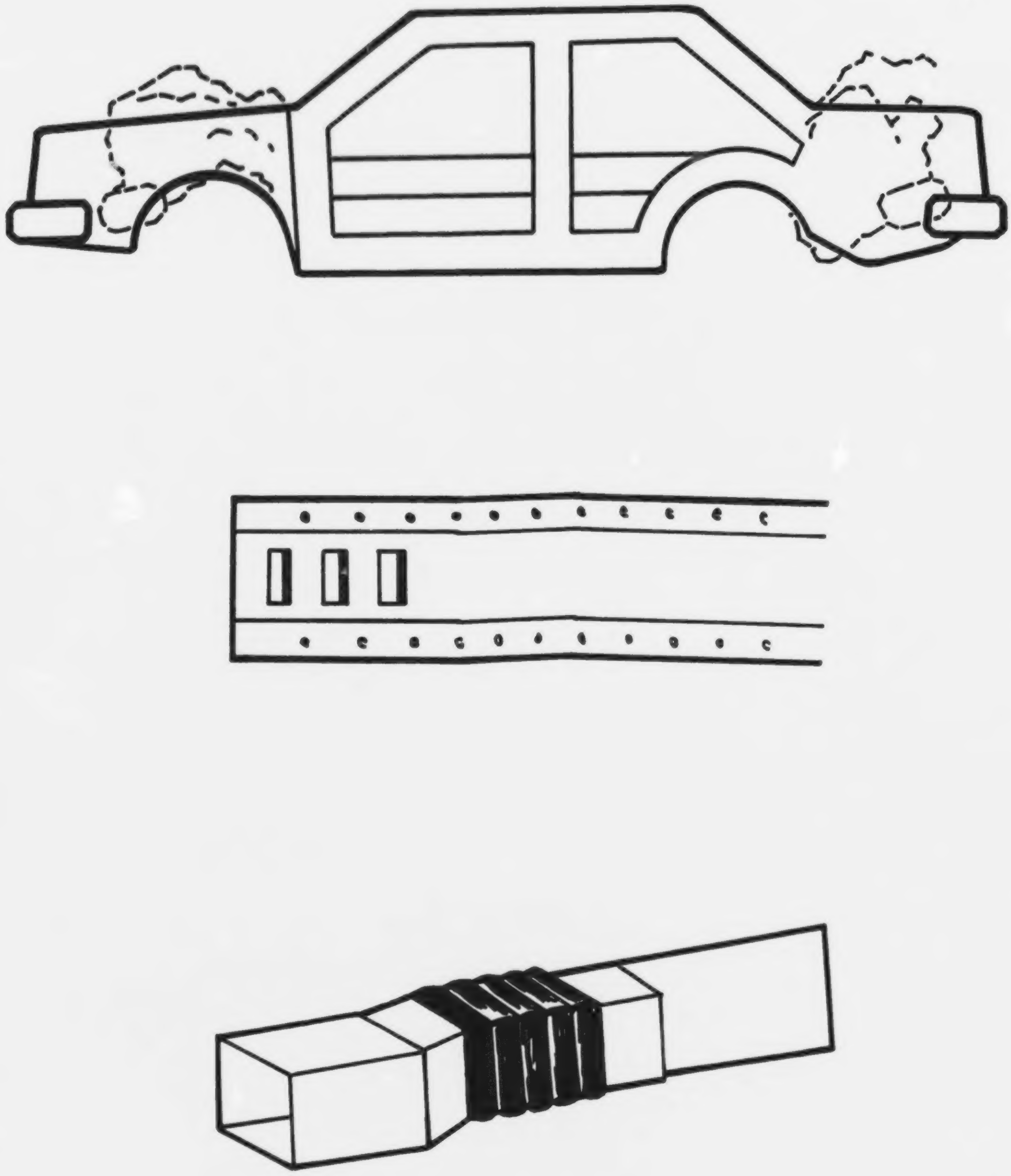
Courtesy of Blackhawk Automotive, Inc.

S-FRAME - 71

HO 2

I-FRAME - 145

Crush Zones



MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT IV: VEHICLE CONSTRUCTION

UNIT IV TEST

PART I–VEHICLE CONSTRUCTION

I. Match the correct illustration with its name.

_____1. Ladder frame

_____2. Later ladder frame

_____3. X-frame

_____4. Hourglass

_____5. Combination

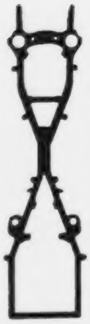
_____6. Perimeter

_____7. Early unitized

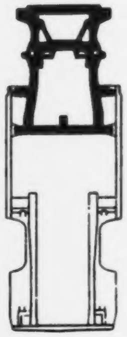
_____8. Bolt-on stub frame

_____9. Present-day unitized

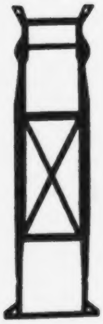
A.



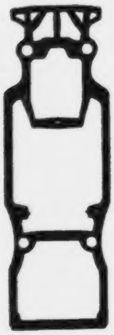
B.



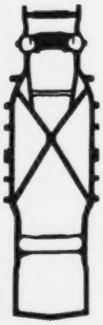
C.



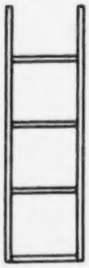
D.



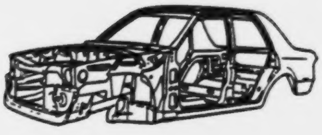
E.



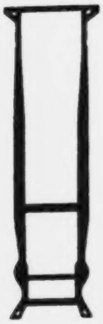
AB.



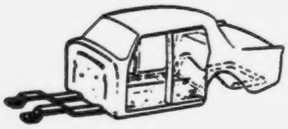
AC.



AD.



AE.



II. Select the best answer from the choices listed.

_____10. The first unitized cars were built in the: (a) 1940s, (b) 1950s, (c) 1960s, (d) 1970s, (e) 1980s.

_____11. The first unitized vehicles were distinguished by partial frame rails which were: (a) bolted to the floor pan, (b) bolted to each other, (c) welded to the floor pan, (d) welded to each other, (e) either bolted or welded to the floor pan.

_____12. The type of vehicle construction using unibody construction for part of the car and frame-body construction for another part is called the: (a) platform frame, (b) partial unibody, (c) bolt-on stub frame, (d) combination frame, (e) perimeter frame.

_____13. In modern unibody construction, structural panels containing complex bends are welded together in such a way that: (a) a smaller, lighter frame can be used, (b) there is no frame, (c) frame rails have been eliminated, (d) the frame and body are no longer separate, (e) the floor pan takes the place of the frame.

_____14. A federal law placing strict fuel economy and emission control standards on automakers was passed in (a) 1974, (b) 1976, (c) 1978, (d) 1980, (e) 1982.

_____15. Which of the following is NOT a characteristic of 1977 model U.S. cars: (a) frame-body construction, (b) 4500-pound fleet average, (c) 18-gauge mild steel, (d) independent front suspension, (e) front engine, front wheel drive.

_____16. Which of the following is NOT a characteristic of 1978 model U.S. cars: (a) frame-body construction, (b) 4200-pound fleet average, (c) 22-gauge HSS, (d) MacPherson-strut front suspension, (e) front engine, rear wheel drive.

_____17. Which of the following is NOT a characteristic of 1980 model U.S. cars: (a) unibody construction, (b) 3600-pound fleet average, (c) 18-gauge mild steel, (d) MacPherson-strut front suspension, (e) transverse front engine, front wheel drive.

_____18. Which of the following is NOT a characteristic of 1985 model U.S. cars: (a) unibody construction, (b) 4500-pound fleet average, (c) 24-gauge HSS, (d) rack-and-pinion steering, (e) transverse front engine, front wheel drive.

III. Match the following with the correct letter(s) in the illustrations.

_____19. Main crossmember

_____20. Stabilizer mount

_____21. Rear crossmember

_____22. Frame horn

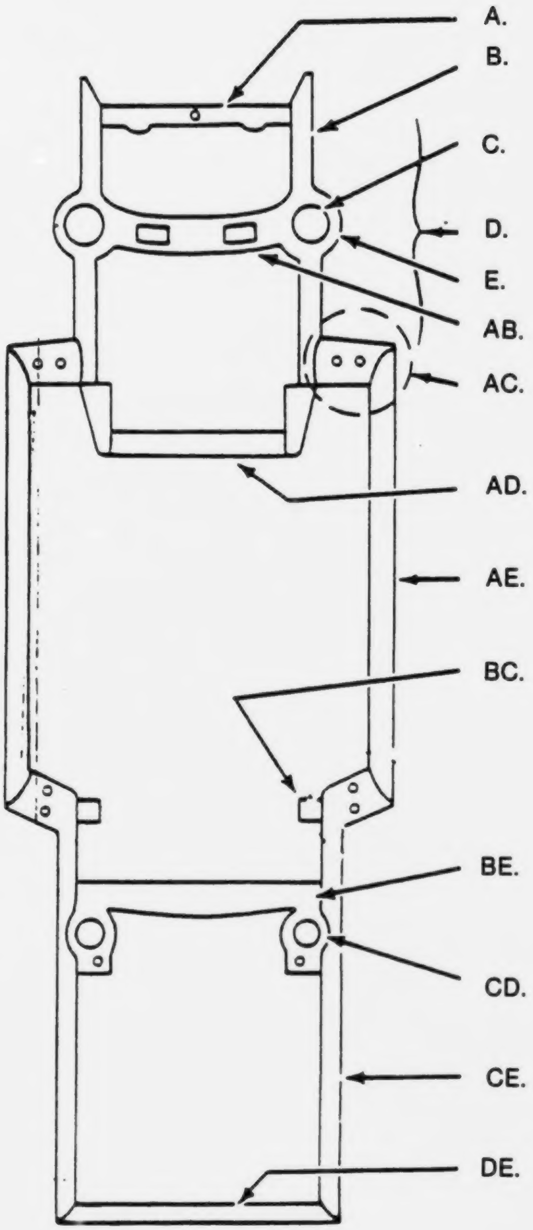
_____23. Transmission support member

_____24. Upper control arm attaching point

_____25. Torque box

_____26. Rear frame rail

_____27. Rear suspension crossmember



IV. Match the following with their correct letter(s) in the illustration.

_____28. A-pillar

_____29. Front apron

_____30. Rear quarter panel

_____31. Rear shock tower

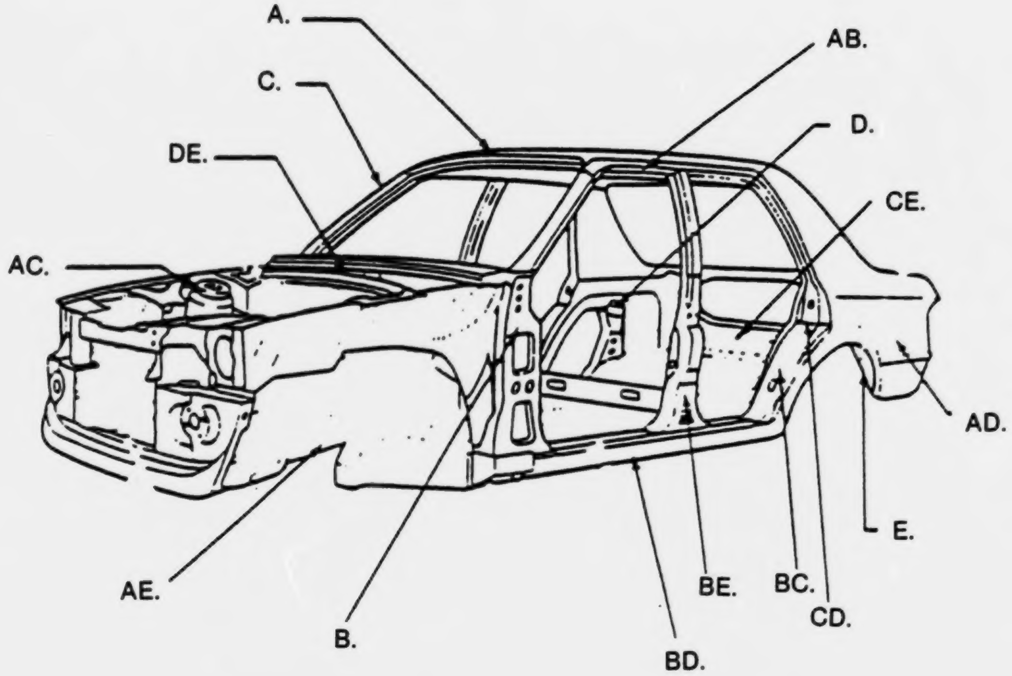
_____32. B-pillar

_____33. Roof side rail

_____34. Strut tower

_____35. Header bar

_____36. Rocker panel assembly



(NOTE: Completion of this unit test is the evaluation for Competencies X1, "Identify vehicle fram construction, conventional and unibody," and X2 "Identify frame and unibody terminology." Of the 36 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this test.)

PART II: IDENTIFY CHARACTERISTICS AND USES OF HIGH-STRENGTH STEELS

I. Choose the best answer from among the choices listed.

_____37. High-strength steel is used in vehicles primarily to achieve: (a) greater strength, (b) safer vehicles, (c) lighter vehicles, (d) unibody vehicles, (e) front-wheel-drive vehicles.

_____38. High-strength steel is generally made by taking mild steel and adding: (a) exotic metals, (b) iron, (c) aluminum, (d) sealers, (d) special resins.

_____39. High-strength steel requires special working considerations because: (a) some HSS is easily damaged by pulling operations, (b) some HSS is subject to warping, (c) some HSS is vulnerable to corrosion, (d) HSS may lose strength when heated, (e) all of the above.

_____40. Ultra-high-strength steel must be identified because: (a) it must be repaired, (b) it gains strength when heated, (c) it must be straightened without heat, (d) it has a tensile strength five times that of mild steel, (e) it cannot be repaired.

_____41. Special aging or dent-resistant steels are formed from steel which: (a) has been made resilient, (b) has been formed at low temperature, (c) is naturally occurring, (d) increases strength after forming, (e) is the strongest of all steels.

_____42. Some high-strength steels can be heated, but only if: (a) a shielding gas is used, (b) a special torch is used, (c) manufacturer's specifications are followed, (d) the car was built since 1982, (e) the car was built since 1985.

_____43. Strength in unibodies comes from high-strength steel, but rigidity comes from: (a) mild steel, (b) complex blends, (c) the frame rails, (d) the rocker panels, (e) the A- and B- pillars.

_____44. An example of the use of ultra-high-strength steel on a Dodge Aries is: (a) the strut tower, (b) the door intrusion beam, (c) the rocker panel, (d) the A-pillar, (e) the B-pillar.

_____45. An example of the use of special aging or dent-resistant steel in a Dodge Aries is: (a) the strut tower, (b) the door instruction beam, (c) the rocker panel, (d) the A-pillar, (e) the B-pillar.

_____46. The reason high-strength steel can reduce the weight of vehicles is because: (a) it is lighter than mild steel, (b) it is lighter than iron, (c) its tensile strength is higher than steel, (d) its tensile strength increases after forming, (e) thinner gauges can be used.

(NOTE: Completion of this portion of the test is the evaluation for Competency X5 "Identify characteristics and uses of high strength steel." Of the 10 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this portion of the test.)

ANSWERS TO UNIT IV TEST

PART I.

1. AB
2. AD
3. C
4. A
5. E
6. D
7. AE
8. B
9. AC

10. A
11. C
12. C
13. D
14. A
15. E
16. D
17. C
18. B

19. AB
20. BC
21. DE
22. B
23. AD
24. C
25. AC
26. CE
27. BE

28. C
29. AE
30. AD
31. D
32. BE
33. AB
34. AC
35. A
36. BD

PART II.

37. C
38. A
39. E
40. E
41. D
42. C
43. B
44. B
45. A
46. E

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT V: TYPES OF DAMAGE AND MEASURING SYSTEMS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify the types of vehicle structural damage and identify measuring systems for structural repair. Mastery will be evidenced by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1: I. Identify terms and definitions (Competency X3, Unit V test)

II. Identify principles of damage analysis (Competency X3, Unit V test)

III. Identify principles of analyzing damage (Competency X3, Unit V test)

IV. Identify the five types of damage (Competency X3, Unit V test)

Lesson 2: I. Identify terms and definitions (Competency X3, Unit V test)

II. Identify the principles of self-centering datum gauge (Competency X3, Unit V test)

III. Identify the principles of tram/tracking gauge (Competency X3, Unit V test)

IV. Identify the principles of principles of the steel tape measure (Competency X3, Unit V test)

V. Identify the use of the tram gauge to measure track (Competency X3, Unit V test)

VI. Identify the principles of universal measuring systems (Competency X3, Unit V test)

VII. Identify the principles of dedicated measuring systems (Competency X3, Unit V test)

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT V: TYPES OF DAMAGE AND MEASURING SYSTEMS

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    b. Transparency masters

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        TM#2: Diamond damage
        TM#3: Twist damage
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    b. Transparency masters

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        TM#2: Alignment of a self-centering gauge
        TM#3: Setting up a tram/tracking gauge
        TM#4: Tram/tracking gauge specifications
        TM#5: Centering gauge alignments
        TM#6: Overlays for sidesway, sag and twist

E. Unit test

F. Answers to unit test

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MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT V: TYPES OF DAMAGE AND MEASURING SYSTEMS

LESSON 1: THE FIVE TYPES OF DAMAGE

I. **Terms and definitions**

A. Center line -- Imaginary plane running through the exact center of the vehicle.

B. Center-to-center dimension -- The distance between the exact centers of two control points.

C. Control points -- Various holes used in measuring alignment which are on the underside of unibody vehicles. Also may refer loosely to any reference point on the vehicle used for damage analysis.

D. Cowl -- The area of the vehicle where the front section joins with the passenger compartment.

E. Datum distance -- The horizontal distance on the datum line between vehicle reference or control points.

F. Datum height -- The vertical distance from control or reference points to the corresponding point on the datum line.

G. Datum line -- An imaginary plane parallel to each vehicle, as determined by manufacturer's specifications. Used as a reference point for vehicle damage analysis.

H. Diamond -- Vehicle damage in which one side of the vehicle is farther forward than the other side, causing the passenger compartment to be out of square.

I. Mash -- Vehicle damage in which the length of any frame member or section is shorter than specifications.

J. Rear torque box area -- The area of the vehicle just ahead of the rear wheels where the passenger compartment connects with the rear section.

K. Reference areas -- The four major areas of the vehicle used for initial damage diagnosis and generally the areas where datum gauges are attached. They are the front cross member, cowl, rear torque box area and rear cross-member. The four reference areas include eight reference points (Also known as controlling points).

L. Sag -- Vehicle damage in which the cowl area is lower than normal.

M. Sidesway -- Vehicle damage in which the front, center or rear compartment of a vehicle is pushed to one side of the vehicle center line.

N. Specifications -- Information provided by the vehicle manufacturer which describes each vehicle, its components and correct dimensions.

O. Twist -- Vehicle damage where one corner of the center section is higher than the diagonally opposite corner.

P. Zone concept – A method of identifying repairs in the initial analysis of damage in which the vehicle is divided into five examination areas or zones.

II. **Principles of damage analysis**

A. Reference lines are needed to analyze vehicle damage.

B. A measuring system is needed to determine the alignment of vehicle with respect to reference lines.

C. The purpose of measuring is to determine if vehicle dimensions are equal to specifications.

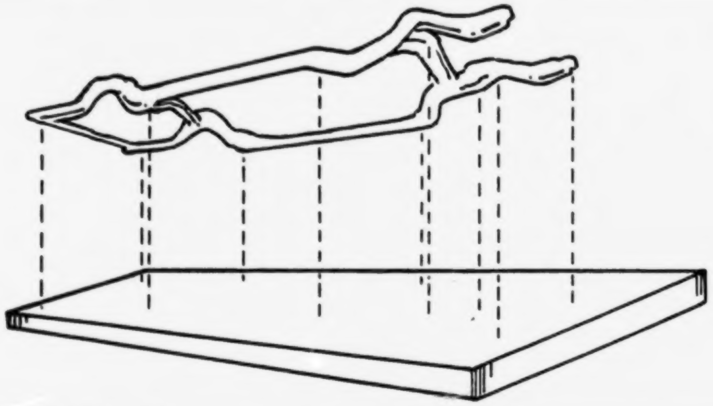
D. There are two reference lines.

1. Datum line

2. Center line

E. Datum line (FIG. 1-1)

FIGURE 1-1

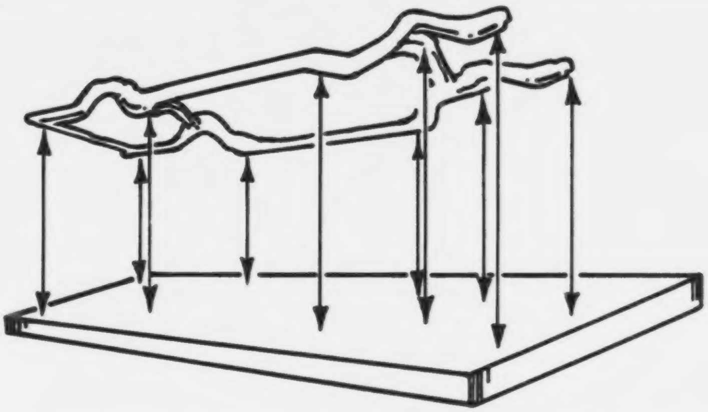


1. Is an imaginary plane underneath vehicle and parallel with the vehicle. Manufacturer's specifications determine datum line

2. Measurements from reference points or control points to datum line reveal sag or twist.

3. Datum height (FIG. 1-2)

FIGURE 1-2



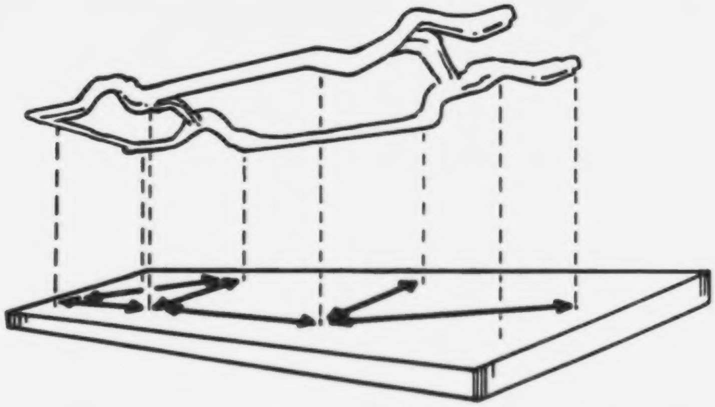
a. Is the distance between control points or reference points and their corresponding point on the datum line

b. Must be measured perpendicular to the datum plane

c. Can reveal sag or twist

4. Datum distance (FIG. 1-3)

FIGURE 1-3



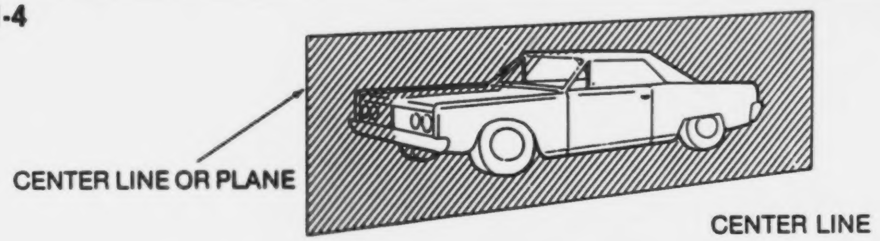
a. Is the distance between control points or reference points as located on the datum plane

b. Must be measured parallel to datum line unless otherwise specified

c. Can reveal length for mash and diagonal distance for diamond

F. Center line (FIG. 1-4)

FIGURE 1-4



1. Is an imaginary line through exact center points of vehicle, established by specifications

2. Is the basis for all lateral measurements

3. Provides the reference plane to measure sidesway in both symmetrical and asymmetrical vehicles

    a. In symmetrical vehicles the distances from the center line to the opposite sides of the vehicle is the same.

    b. In non-symmetrical vehicles the distances from the center line to the opposite sides of the vehicle is not the same. Vehicle specifications reveal asymmetrical distances.

G. Three-section concept of vehicle construction

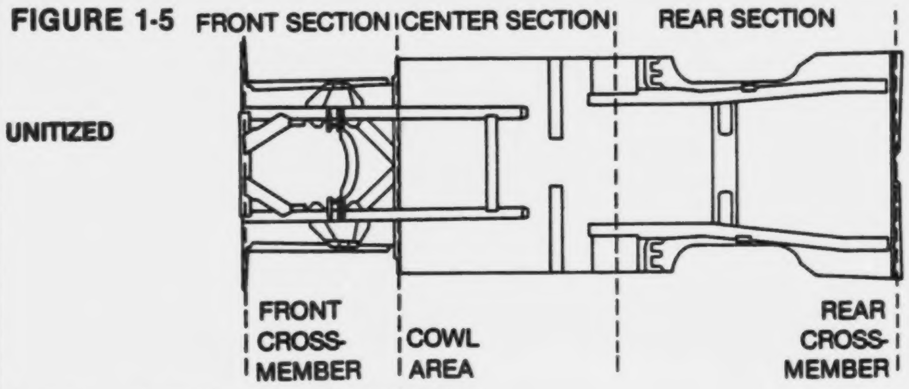
1. Both conventional and unibody vehicles have three sections. (FIG. 1-5), (FIG. 1-6)

    a. Front section

    b. Center section (passenger compartment)

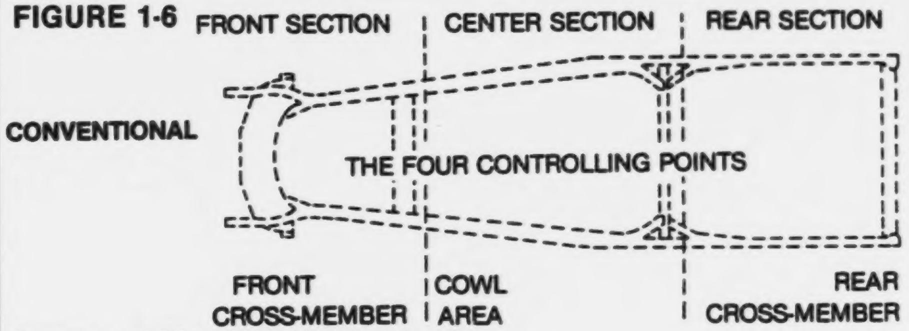
    c. Rear section

FIGURE 1-5


FRONT SECTION
CENTER SECTION
REAR SECTION
UNITIZED
FRONT CROSS-MEMBER
COWL AREA
REAR CROSS-MEMBER

Courtesy of Blackhawk Automotive, Inc.

FIGURE 1-6


FRONT SECTION
CENTER SECTION
REAR SECTION
CONVENTIONAL
THE FOUR CONTROLLING POINTS
FRONT CROSS-MEMBER
COWL AREA
REAR CROSS-MEMBER

Courtesy of Blackhawk Automotive, Inc.

2. The cowl area is generally the dividing line between front and center section.

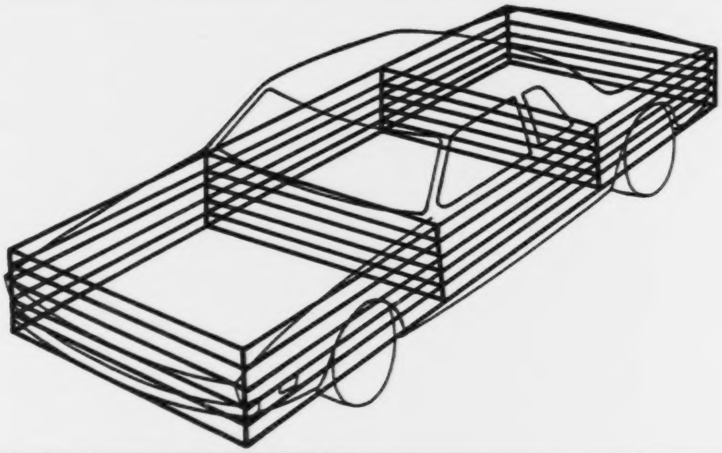
3. Rear torque box area generally is the dividing line between center and rear section.

4. There are four main reference areas, involving eight reference points.

   (NOTE: Although there are at least eight reference points, some vehicles have additional reference points.)

5. Damage can be visualized by thinking of vehicle as being composed of three adjacent boxes. (FIG. 1-7)

FIGURE 1-7



H. Zone system for analyzing unibody damage

1. Developed by the Inter-Industry Conference on Auto Collision Repair.

2. Divides damage into five zones.

   a. Zone 1 is the area of damage directly resulting from the impact (Primary damage).

   b. Zone 2 is the rest of the body, including the damage incurred by the force of the impact traveling through the structure.

   c. Zone 3 is damage to mechanical components (suspension and drive train).

   d. Zone 4 is the passenger compartment.

   e. Zone 5 is the exterior components of the vehicle, including all trim.

I. Control points

1. For frame-body and unibody construction

   a. Control points are easily identifiable parts or points on the underside of the vehicle or in the engine compartment.

   b. Factory specifications will locate control points.

2. For unibody construction only

   a. Control points are usually holes in components used as fixturing points in the factory to build frames to close tolerances of 3 mm for overall body length.

b. Control point may differ on two examples of the exact same model vehicle, depending on where vehicle was manufactured.

3. Measuring control point center-to-center dimensions

a. When measuring distances between holes in components, measure from the center of the hole, if possible, as stated in specifications.

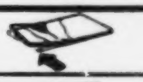
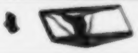
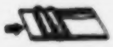
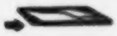
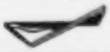
b. If holes are of same size and are not damaged, measure the like edge-to-like-edge distance.

c. If measuring between two holes of different sizes, measure inside edge-to-inside-edge dimension and outside edge-to-outside-edge dimension, then add the two figures together and divide by two to find center-to-center dimension.

III. Analyzing damage

A. Vehicle frame damage, whether conventional or unibody, falls into one of five types of damage, or a combination of two or more of the five types. (FIG. 1-8)

FIGURE 1-8

DAMAGE TYPES	
	SIDESWAY
	SAG
	MASH
	DIAMOND
	TWIST

Courtesy of Blackhawk Automotive, Inc.

B. Each of the five types is described by the relationship of the reference points (or control points) to datum line, datum distance, and/or center line.

C. Diamond and Twist damage occur only in the center section of the vehicle.

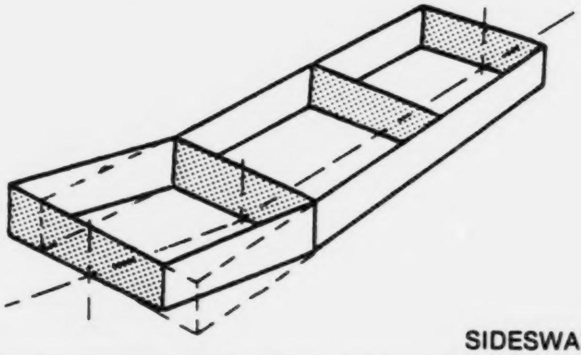
D. Mash, sag and sidesway may occur in front, center or rear sections.

E. Diamond damage seldom occurs in unibody vehicles and when it does, the vehicle is almost always damaged beyond economical repair.

(NOTE: Frequently, damage of two or more types occurs to a vehicle in the same collision. Damage analysis must always be made with this in mind. Check for all types of damage.)

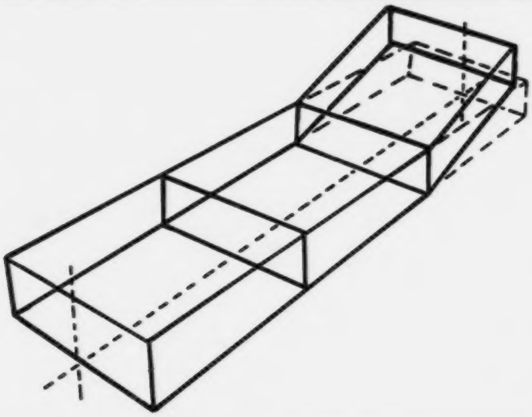
F. The five types of damage may be visualized with the box section representation. (FIG. 1-9, 1-10, 1-11, 1-12, 1-13)

FIGURE 1-9



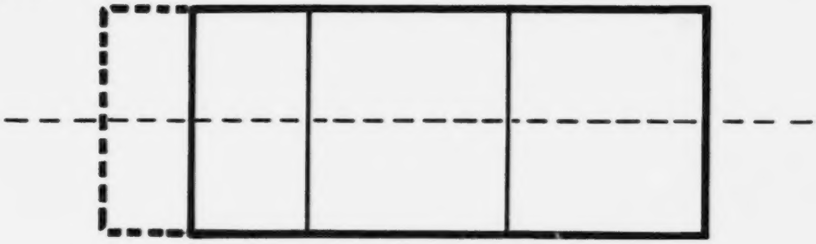
SIDESWAY

FIGURE 1-10



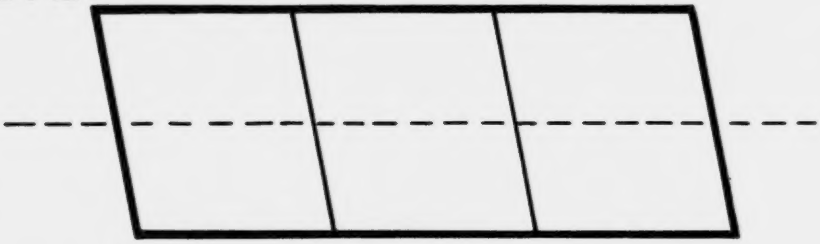
SAG

FIGURE 1-11



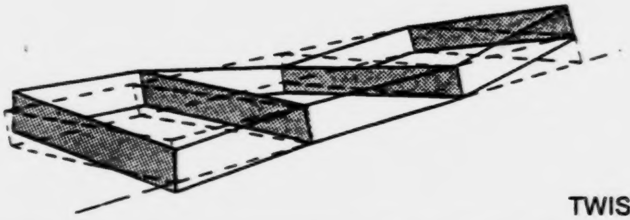
MASH

FIGURE 1-12



DIAMOND

FIGURE 1-13



TWIST

VII. Recognizing the five types of damage

A. Diamond damage

1. Is recognized by the center section of vehicle being out of square, with one side of the passenger compartment pushed ahead of the other side.

2. Diagonal measurements of center section reveal diamond damage (if diagonal measurements are not equal, vehicle has diamond damage). Diamond is measured as one-half the difference in the distances. A car with four inches difference between the measurements has a diamond condition of two (one-half of four).

B. Twist damage

1. Recognized by one corner of the center section being higher that its diagonally opposite corner.

2. Center section reference point datum height measurements reveal twist damage.

C. Mash damage

1. Recognized by one section of the vehicle or frame member being shorter than specifications.

2. Datum distance reveals mash damage.

D. Sag damage

1. Is recognized by cowl area being lower than specifications.

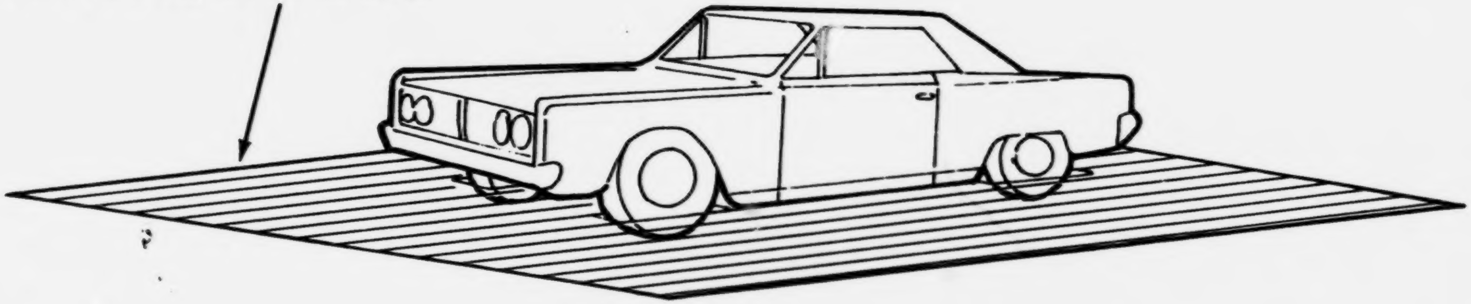
2. Datum height reveals sag damage.

E. Sidesway damage

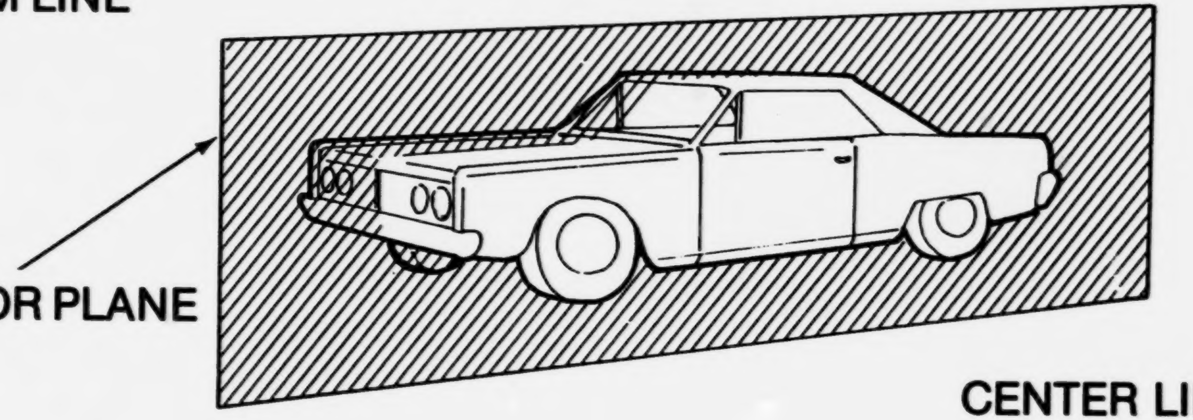
1. Is recognized by any portion of vehicle being out of line with centerline.

2. Centerline reveals sidesway damage.

Datum and Center Lines

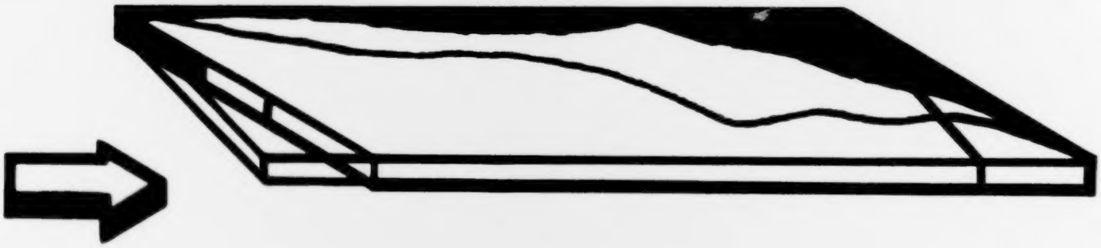

DATUM LINE OR PLANE

DATUM LINE

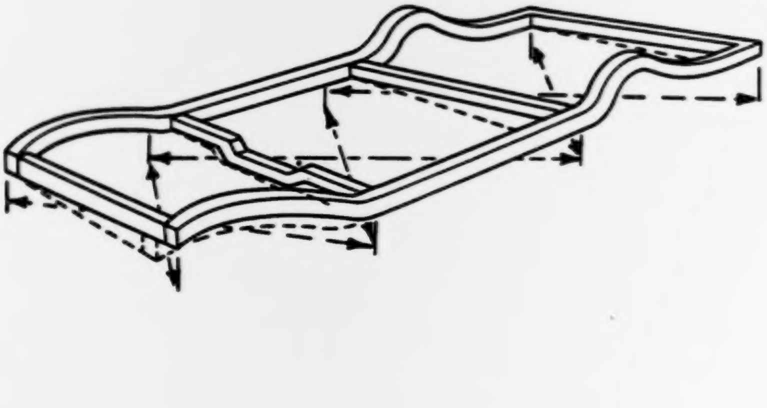

CENTER LINE OR PLANE

CENTER LINE

Diamond

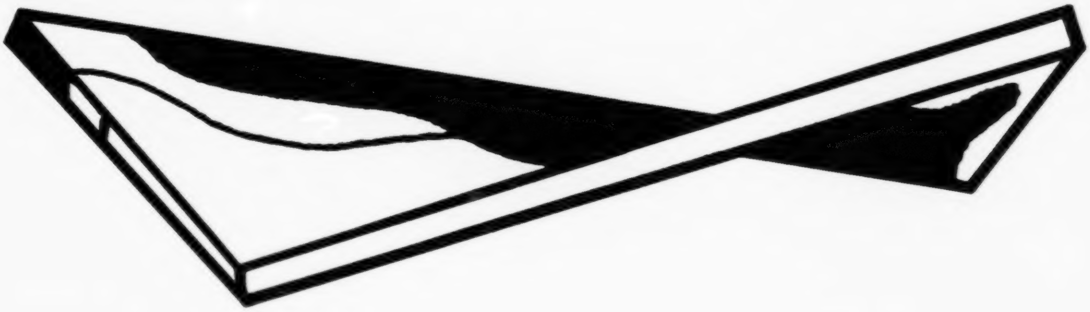


MAKING THE MEASUREMENTS THAT WILL IDENTIFY DIAMOND DAMAGE.

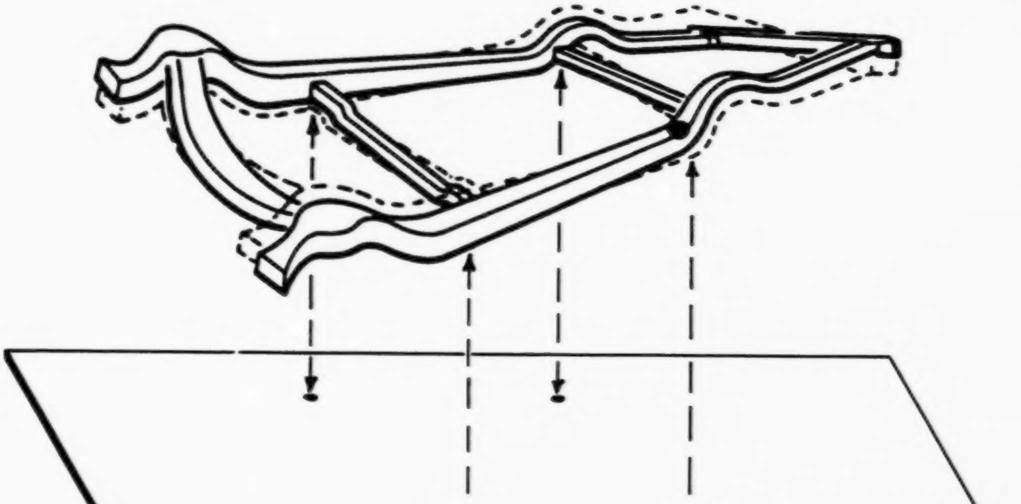


Courtesy of Blackhawk Automotive, Inc.

Twist

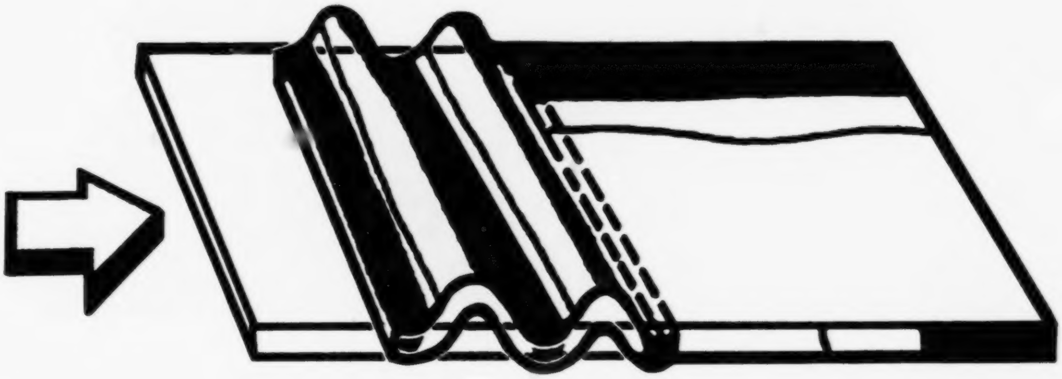


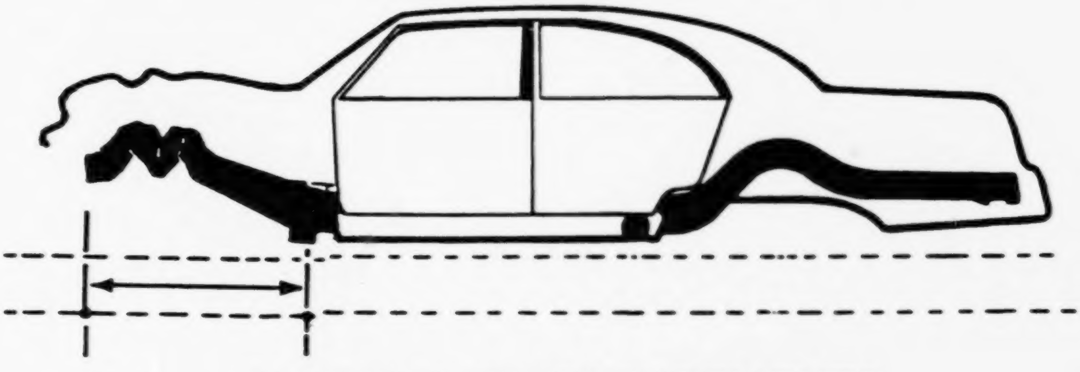
MAKING THE MEASUREMENTS THAT WILL IDENTIFY TWIST DAMAGE.



Courtesy of Blackhawk Automotive, Inc.

Mash

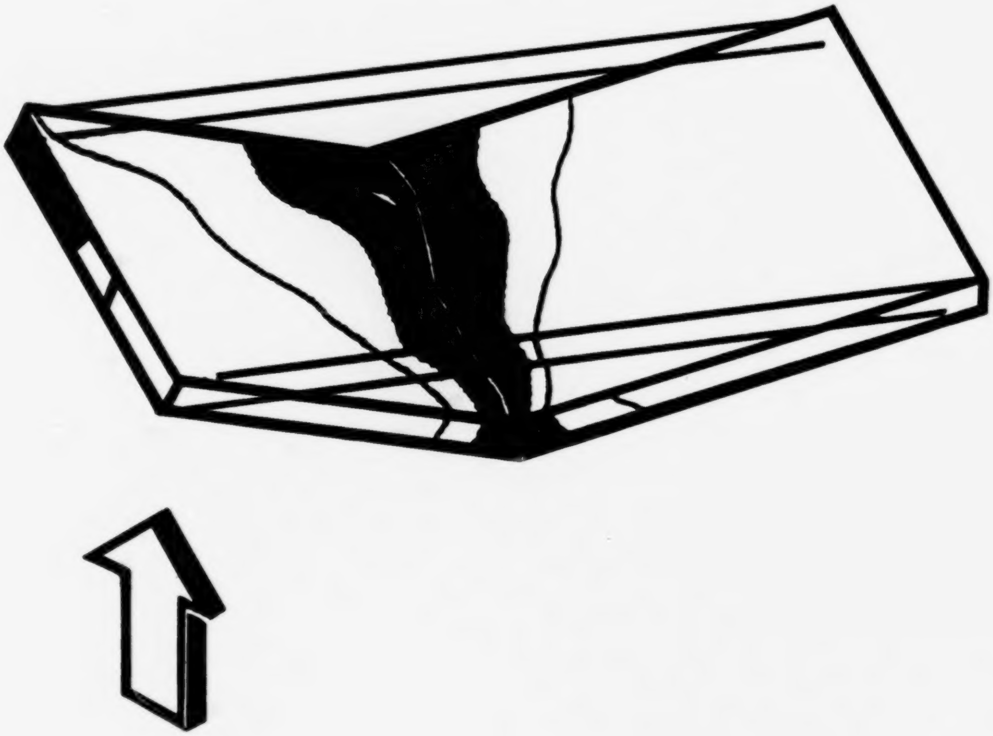




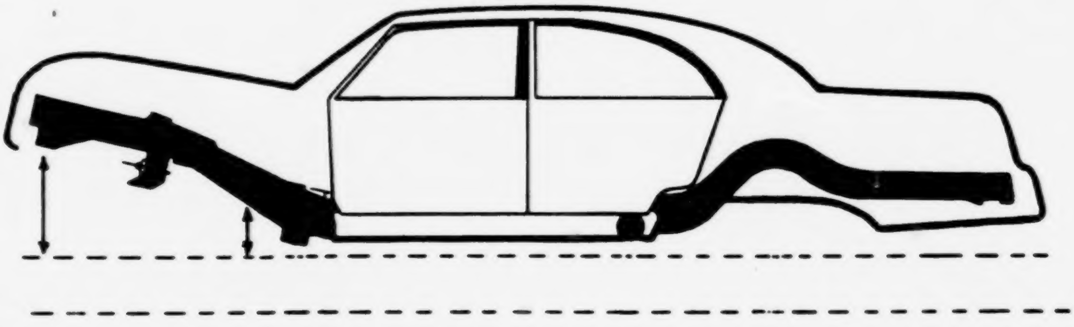
MAKING THE MEASUREMENTS
THAT WILL IDENTIFY MASH DAMAGE.

Courtesy of Blackhawk Automotive, Inc.

Sag

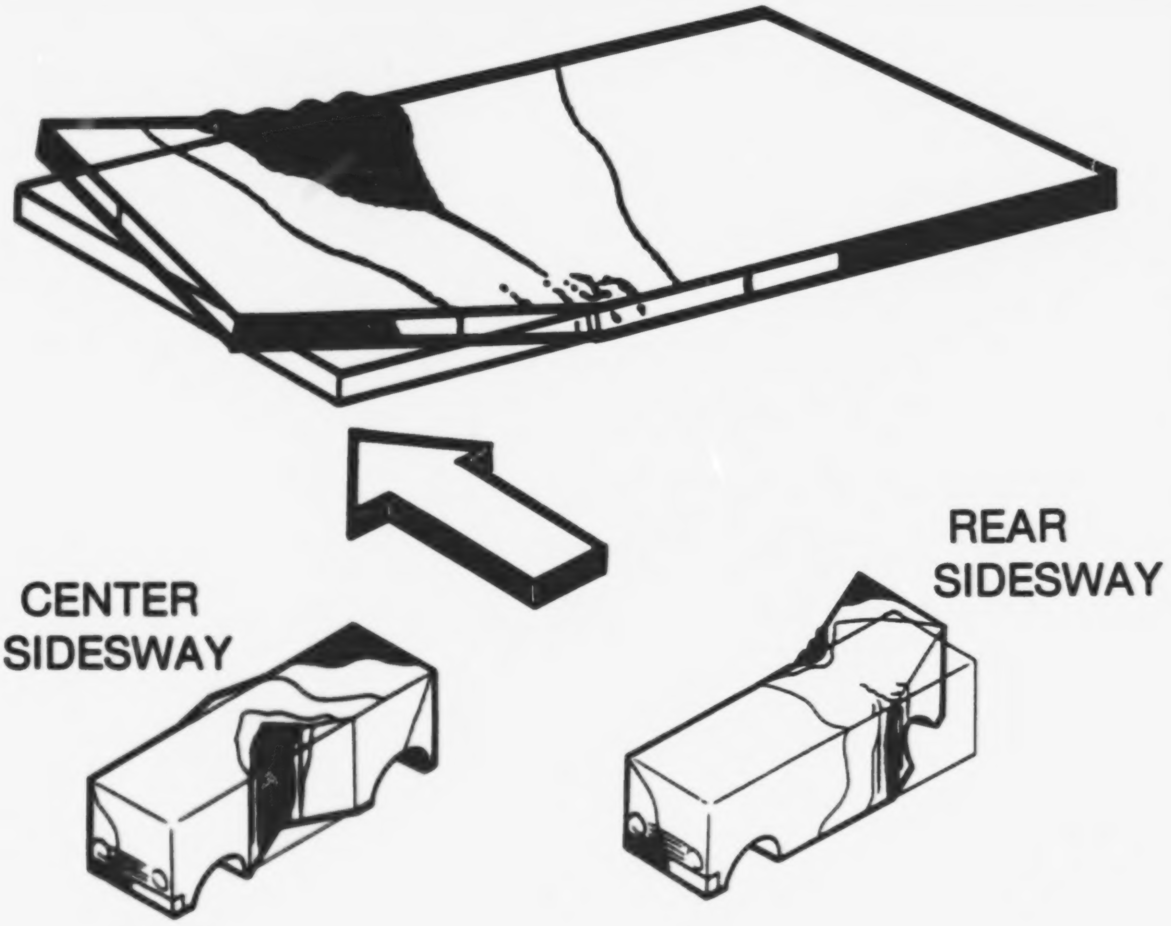


MAKING THE MEASUREMENTS
THAT WILL IDENTIFY SAG DAMAGE.

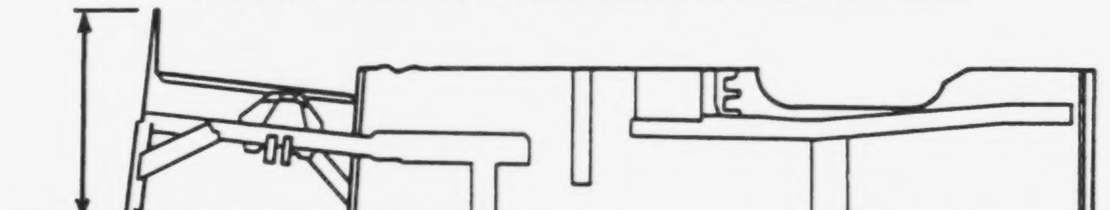


Courtesy of Blackhawk Automotive, Inc.

Sidesway


REAR
SIDESWAY
CENTER
SIDESWAY

MAKING THE MEASUREMENTS THAT WILL IDENTIFY SIDESWAY DAMAGE.



Courtesy of Blackhawk Automotive, Inc.

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT V: TYPES OF DAMAGE AND MEASURING SYSTEMS

LESSON 2: GAUGING SYSTEMS

I. **Terms and definitions**

A. Calibrate – To check and correct the setting of a device used for measuring vehicle damage.

B. Dedicated fixture measuring system (Dedicated bench) – A unibody repair system in which fixtures designed for a family of body styles are mounted on a special bench, providing exact measuring points.

C. Frame gauges – Special gauges that are hung from the frame to check the frame alignment.

D. Gauge – Using measuring equipment to determine vehicle's relationship to factory specifications.

E. Graduation – Marks on a measuring device showing the unit or units of measurement employed.

F. Laser universal measuring system – A frame repair measuring system in which a laser is aimed at calibrated targets hung from the vehicle, measuring several control points at the same time.

G. Measuring System – A complete set of equipment used to analyze damage and measure repair progress in frame and unibody repair operations.

H. Mechanical universal measuring system – A frame repair measuring system in which pointers are mounted onto a measurement bridge configuration according to the vehicle's correct dimensions.

I. Non-symmetrical (asymmetrical) – Vehicle construction in which the distances from the center line to corresponding points on each side of vehicle are not the same.

J. Self-centering datum gauge – A frame repair measuring system which is hung from the bottom of a vehicle to establish the vehicle's datum line. By hanging at least four gauges, center line and datum line are both shown. Also known as datum gauge.

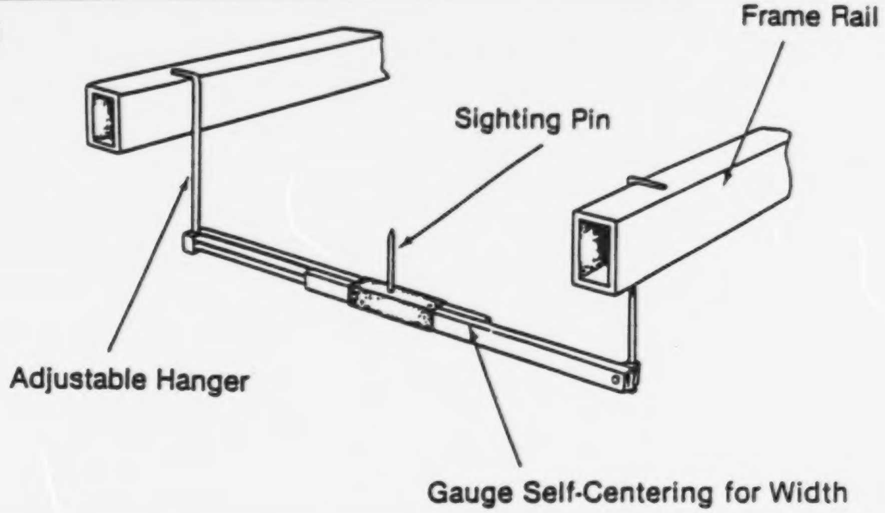
K. Universal measuring system – A frame repair measuring system, either mechanical or laser, which measures many control dimensions at the same time.

L. Symmetrical – Vehicle construction in which the distances from center line to corresponding points on each side of vehicle are all the same.

M. Tram/tracking gauge – A frame repair measuring system in which two pointers are mounted on and at right angles to a bar and can make measurements over an obstruction. Can also be set to make datum distance measurements over an obstructions. Used for length and diamond measurements and tracking.

II. The self-centering datum gauge (Datum gauge) (FIG. 2-1)

FIG. 2-1



A. Visually establishes vehicle's relationship to both centerline and datum line. Does not measure distances.

B. Is hung from vehicle underbody reference points.

C. Advantages

1. Provides continuous check of datum and center lines during repair from either end of vehicle, if left on vehicle during repairs.

   (NOTE: Gauges are usually removed to prevent damage to gauges during pulling operations).

2. Requires a minimal investment.

3. Can be used on frame-body and, with special hookups, on unitized construction.

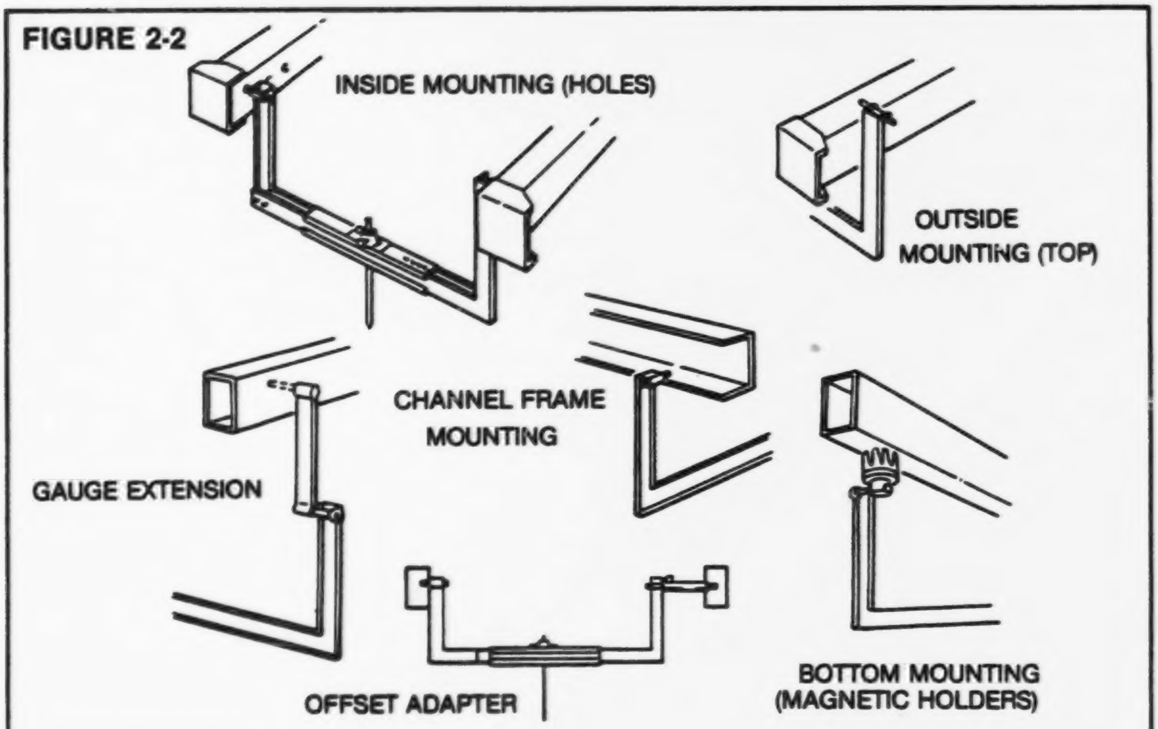
D. Disadvantages

1. Must be used with tram gauge for datum distance and/or a tape measure where necessary.

2. Difficult to use on non-symmetrical vehicles unless datum gauges that are not self-centering are used.

E. Methods of installing self-centering datum gauges (FIG. 2-2)

FIGURE 2-2


INSIDE MOUNTING (HOLES)
OUTSIDE MOUNTING (TOP)
CHANNEL FRAME MOUNTING
GAUGE EXTENSION
BOTTOM MOUNTING (MAGNETIC HOLDERS)
OFFSET ADAPTER

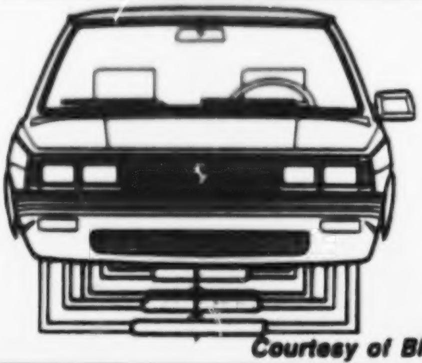
1. Mounted in a hole
2. Resting on top of frame rail or member
3. Hung with extension
4. Hung with offset adapter (adapter must be one specifically for that vehicle)
5. Hung inside channel frame member
6. Hung with magnetic attachment

(NOTE: In some cases it may be necessary to use a wire loop or a clamp, such as a C-clamp, to attach the datum gauge to the frame.)

F. Principles of using self-centering gauge configurations to reveal types of damage. (FIG. 2-3, 2-4, 2-5)

(NOTE: Sag, side sway and twist are easily revealed.)

FIGURE 2-3

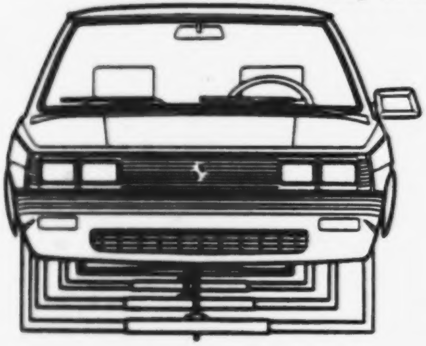


SAG

Courtesy of Blackhawk Automotive, Inc.

FIGURE 2-4

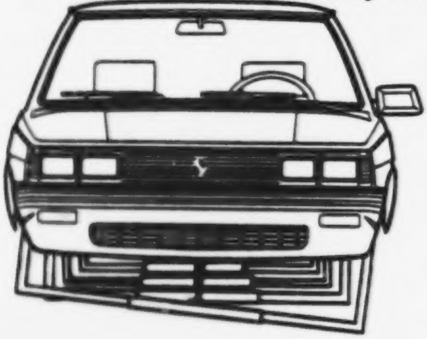
Courtesy of Blackhawk Automotive, Inc.



SIDESWAY

FIGURE 2-5

Courtesy of Blackhawk Automotive, Inc.



TWIST

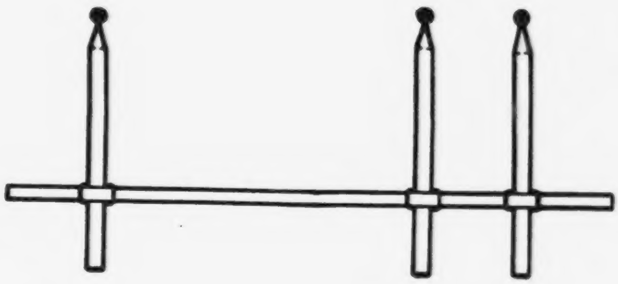
1. At least four gauges must be used.

2. The gauges must be mounted at or near reference areas, or as near as possible (one at extreme front, one at extreme rear, one rearward of the front wheels and one forward of the rear wheels).

3. Combination damage requires careful attention. Extensive measuring is often required to reveal combinations of two or more types of damage.

III. Tram/tracking gauge (FIG. 2-6)

FIGURE 2-6



A. Establishes point-to-point distances between reference points, including diagonal measurements; when properly set, tram gauge also establishes datum line and can measure datum distance. Can also measure track.

B. Is used to measure over obstructions.

(NOTE: Tram gauges generally will be used to measure from hole to hole. If tram gauge tips are larger than holes, use procedure for measuring center-to-center dimensions from Lesson Two. The best areas for tram gauge measurements include attachment points for suspension and mechanical parts.)

C. Advantages

1. Requires minimal investment.

2. Can measure frame-body and unitized construction.

D. Disadvantages

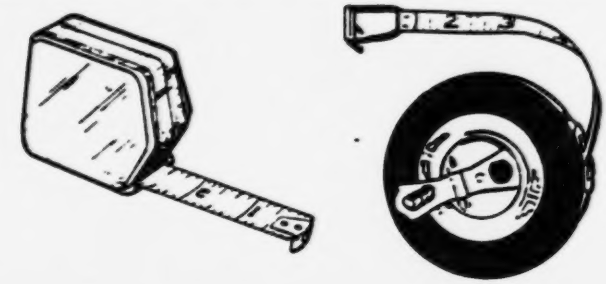
1. Records only one dimension at a time and each dimension must be cross-checked from two other control points, at least one of which should be a diagonal measure.

2. Difficult for one person to operate with accuracy.

   (NOTE: The tram gauge, the self-centering datum gauge and the steel tape measure are considered to form one measuring system. Used together they can measure all forms of distortion, but not all the disadvantages are overcome by combining them).

IV. The steel tape measure (FIG. 2-7)

FIGURE 2-7



A. May be used to measure point-to-point dimensions on unobstructed areas of vehicle.

B. Is stretched tight between two points.

C. Advantages

   1. Provides quick measurement check, where practical, on both frame-body and unitized construction.
   2. Can be used to calibrate tram gauge or to check calibrations on other equipment.
   3. Requires very minimal investment.

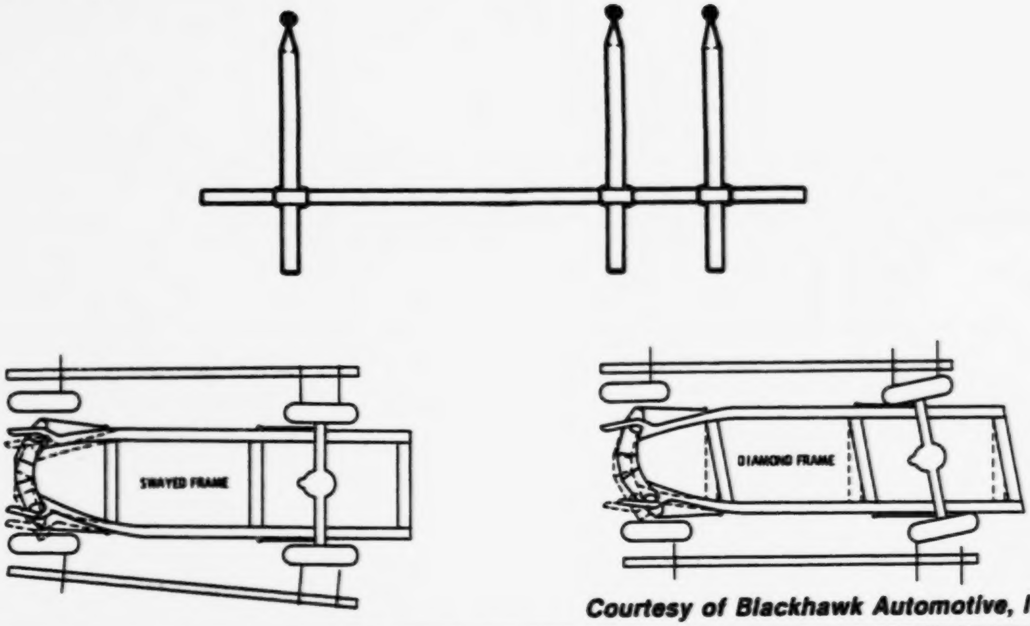
D. Disadvantages

   1. Establishes only point-to-point distances and obstructions must be disassembled.
   2. Is difficult to obtain readings accurate enough for unibody repair.

   (Note: The steel tape, usually six- or 12-foot length, is generally used with all repair systems. Tapes with both metric and fractional-inch scales are needed)

V. Tram/tracking gauge used to check track (FIG. 2-8)

FIGURE 2-8



Courtesy of Blackhawk Automotive, Inc.

A. Shows when front wheels and rear wheels are in proper alignment with each other.

B. Easy to use, with pointers placed on wheels.

C. Advantages

   1. Necessary as an additional measuring component in systems that do not measure track.

   2. Can be used on both frame-body and unitized vehicles.

   3. A quick indicator of damage.

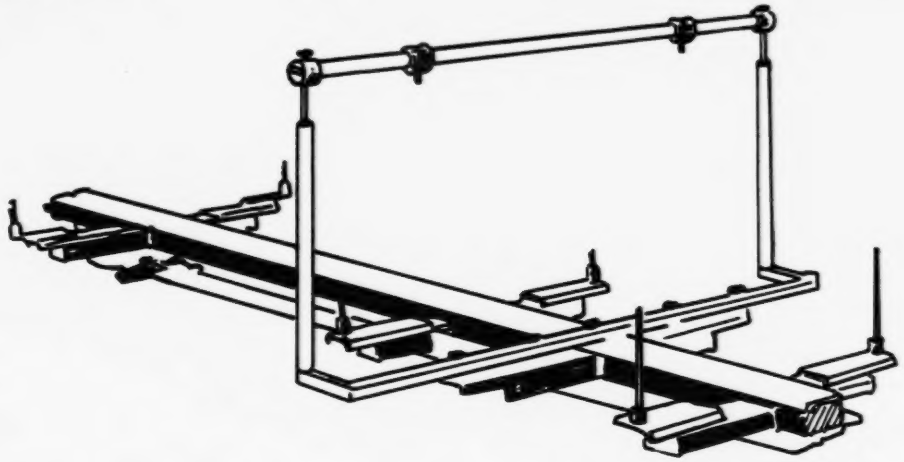
D. Disadvantages

   1. Does not reveal the cause of tracking misalignment. (Although certain damage types may be indicated as possibilities, other measuring systems must be used to be certain of exact nature of damage).

VI. Universal measuring systems

A. Mechanical systems (FIG. 2-9)

FIGURE 2-9



1. Can measure all dimensions and control points referenced to factory specifications.

2. Employs precision measurement bridges with mechanical pointers attached to bridges; pointers set with points located at control points and reference points according to vehicle specifications.

3. Advantages

   a. Allows simultaneous observation of many control points.

   b. Can be use on unitized construction.

   c. Can be set up and operated by one person.

4. Disadvantages

   a. Vulnerable to operator error.

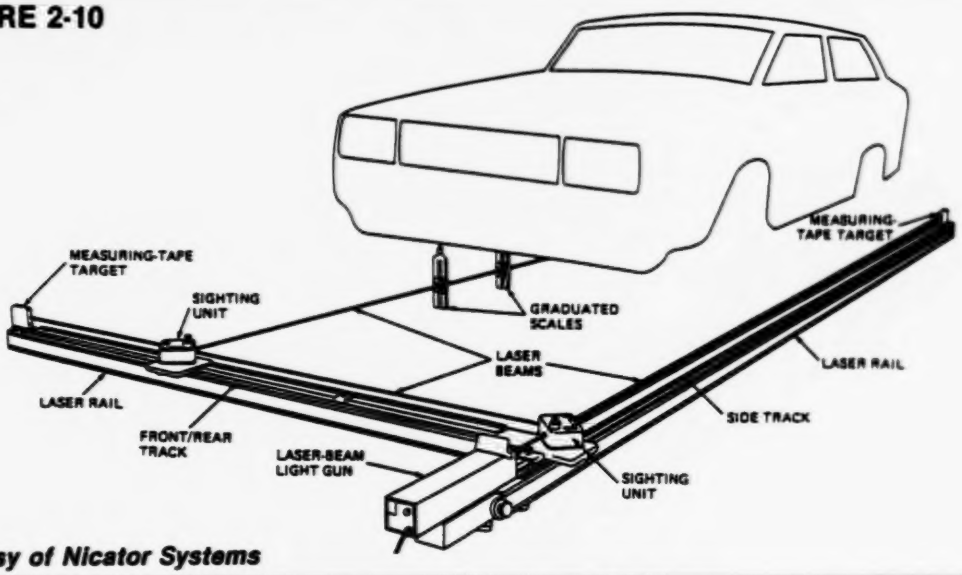
   b. The measurement bridges may be damaged during pulling procedures if care is not taken to determine if and where pull procedure may put pressure on pointers or bridges.

   c. Some types of universal mechanical systems may have to be removed during pulling operations.

   d. If damaged, it may have to be returned to factory to be recalibrated.

B. Laser systems (FIG. 2-10)

FIGURE 2-10


MEASURING-TAPE TARGET
SIGHTING UNIT
GRADUATED SCALES
LASER BEAMS
LASER RAIL
FRONT/REAR TRACK
LASER-BEAM LIGHT GUN
SIGHTING UNIT
SIDE TRACK
LASER RAIL
MEASURING-TAPE TARGET

Courtesy of Nicator Systems

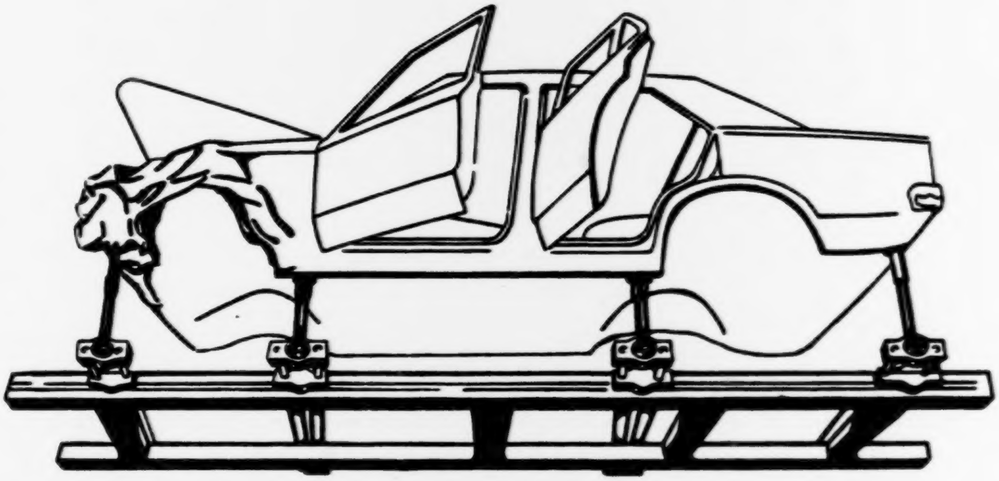
1. Can measure all forms of distortion, including track.
2. Can be used on both frame-body and unitized vehicles.
3. Measurement is made by aiming a laser beam at calibrated targets, with targets hung from car or from a bar attached to car; laser sources mounted to car or to bench.
4. Advantages
    a. The system can generally remain in place during pulling procedure.
    b. Allows simultaneous readings of control points all around the vehicle.
    c. Can be set up and operated by one person.
    d. The measurement does not interfere with repair.
    e. Can be used before, during and after repair.
5. Disadvantages
    a. Appears complicated; operator error is frequent unless operator is well-instructed.
    b. Continuous monitoring of measuring scales is required.
    c. Does not measure datum distance, length or diagonal (system measures control point's relationship to true).

d. Tedious to calibrate.

e. Targets are fragile.

f. All calibrated targets must be optically perfect or should be discarded.

C. The universal bench (FIG. 2-11)



Courtesy of Chart Industries, Ltd.

1. Resembles a dedicated bench but does not have fixtures for each vehicle family.

2. Uses at least four universal fixture points, one in each torque box area, which can be adjusted for each vehicle.

3. Advantages

   a. Allows for efficient operation of some mechanical measuring systems.

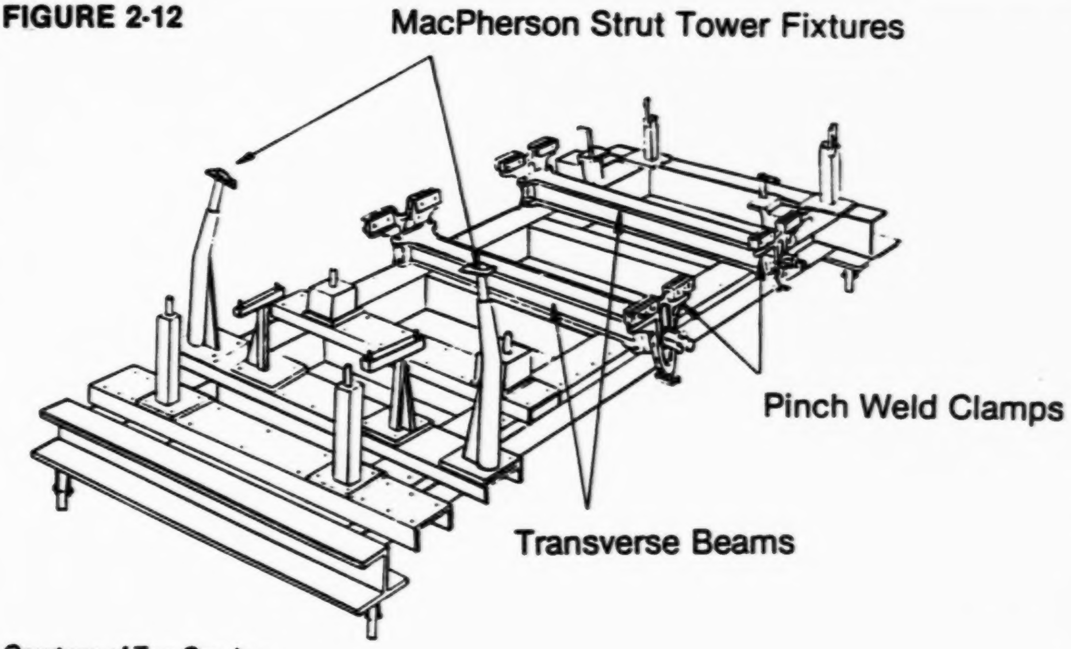
   b. Provides vehicle anchoring during repairs.

4. Disadvantages

   a. Can only be used on unitized construction.

VII. The dedicated bench (FIG. 2-12)

FIGURE 2-12



Courtesy of Tec-Cor. Inc.

A. Measures all distortion to exact factory specifications; reveals distortion without measurements being taken.

B. Vehicle is placed on bench with fixtures on bench set to line up with control points on that particular vehicle, according to exact factory specifications.

C. Advantages

  1. Assures that there is no possibility of measurement error as long as fixtures are placed at correct location.

  2. Allows simultaneous observation of all control points.

  3. Acts as fixture for replacing panels.

  4. Can be set up and operated easily by one person.

  5. Bench without fixtures can be used as a universal bench.

D. Disadvantages

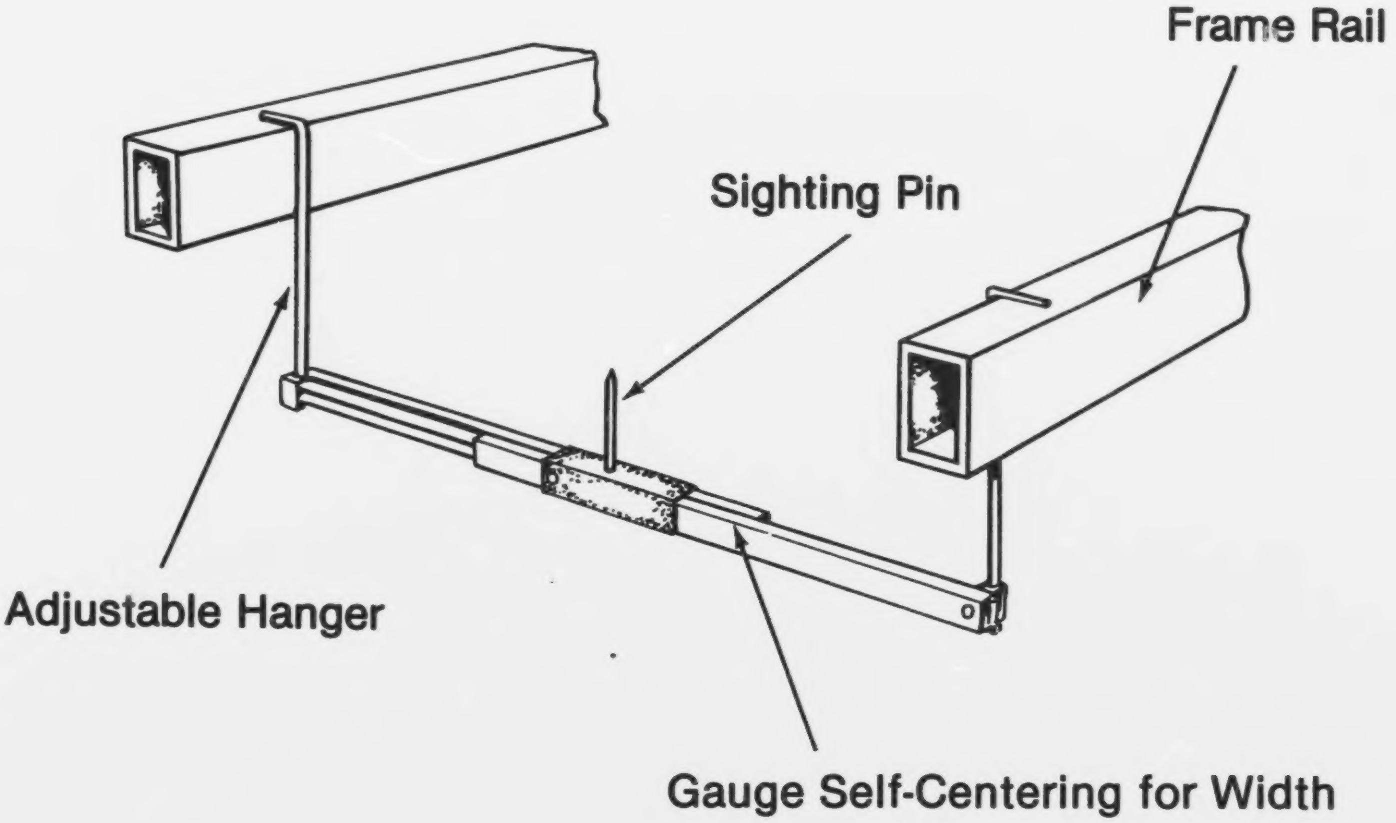
  1. Designed for use only with unitized construction.

  2. Fixtures must be purchased or rented for each type of vehicle or family of vehicles and must come from the same manufacturer as bench.

3. Requires a high initial investment plus the continued cost of new fixtures as needed for new car families.

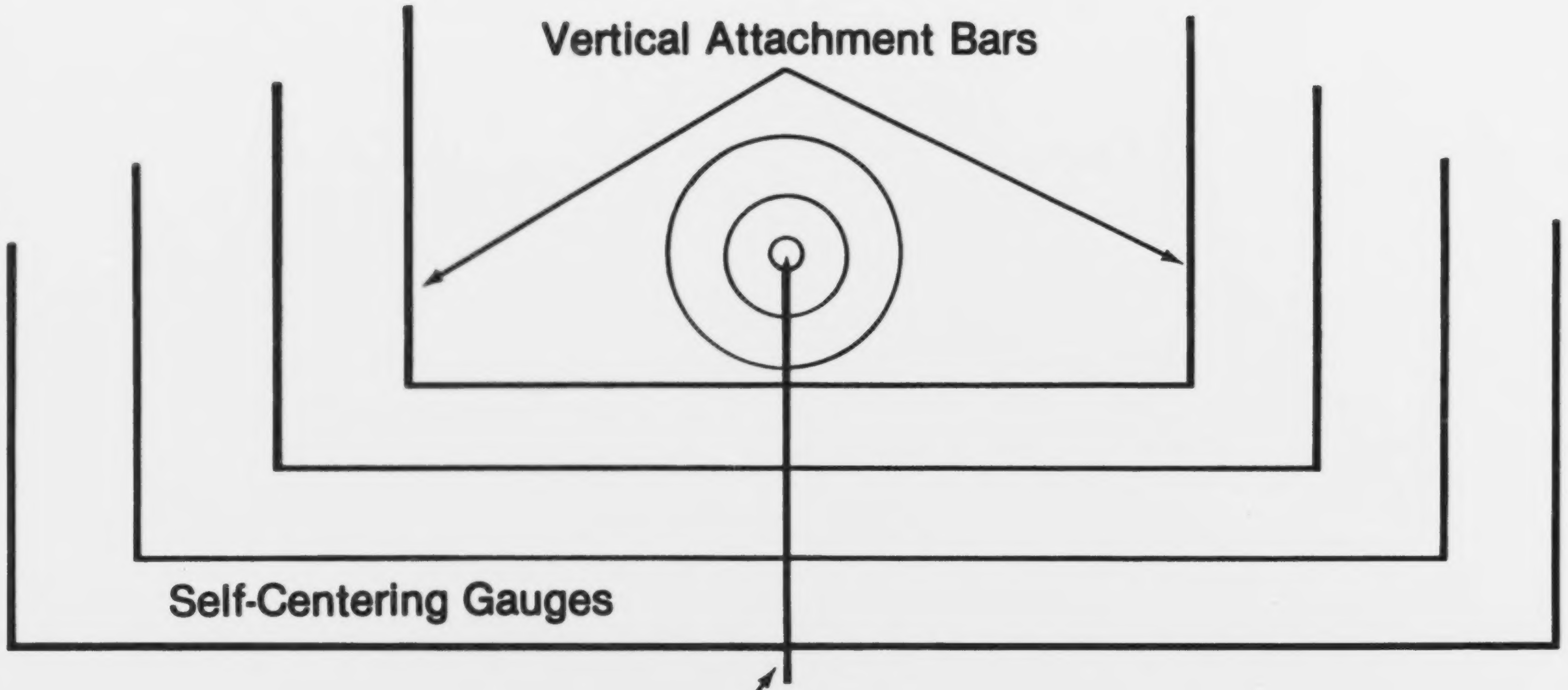
(NOTE: There are four types of measuring systems. 1. Self-centering gauges combined with a tram gauge and steel tape measure; 2. The mechanical universal system, 3. The laser universal system, 4. The dedicated bench system. All four systems must use factory specifications or an undamaged vehicle of the same year and model for reference).

Self-Centering Gauge


Frame Rail
Sighting Pin
Adjustable Hanger
Gauge Self-Centering for Width

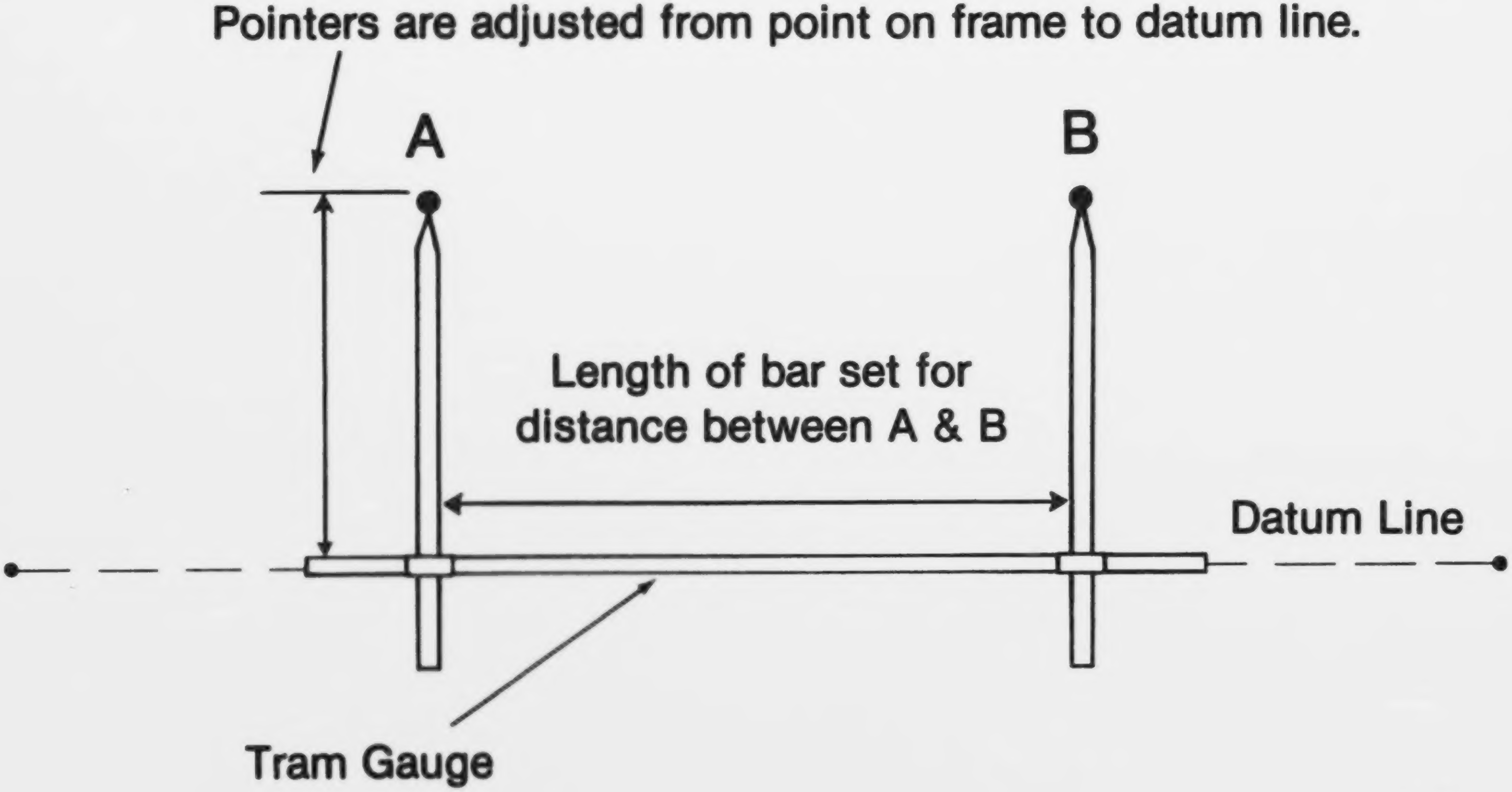
TM 1

Alignment of Self-Centering Gauges


Vertical Attachment Bars
Self-Centering Gauges

Center line is established when sight pins line up with each other.

Setting Up a Tram Gauge



Pointers are adjusted from point on frame to datum line.

A

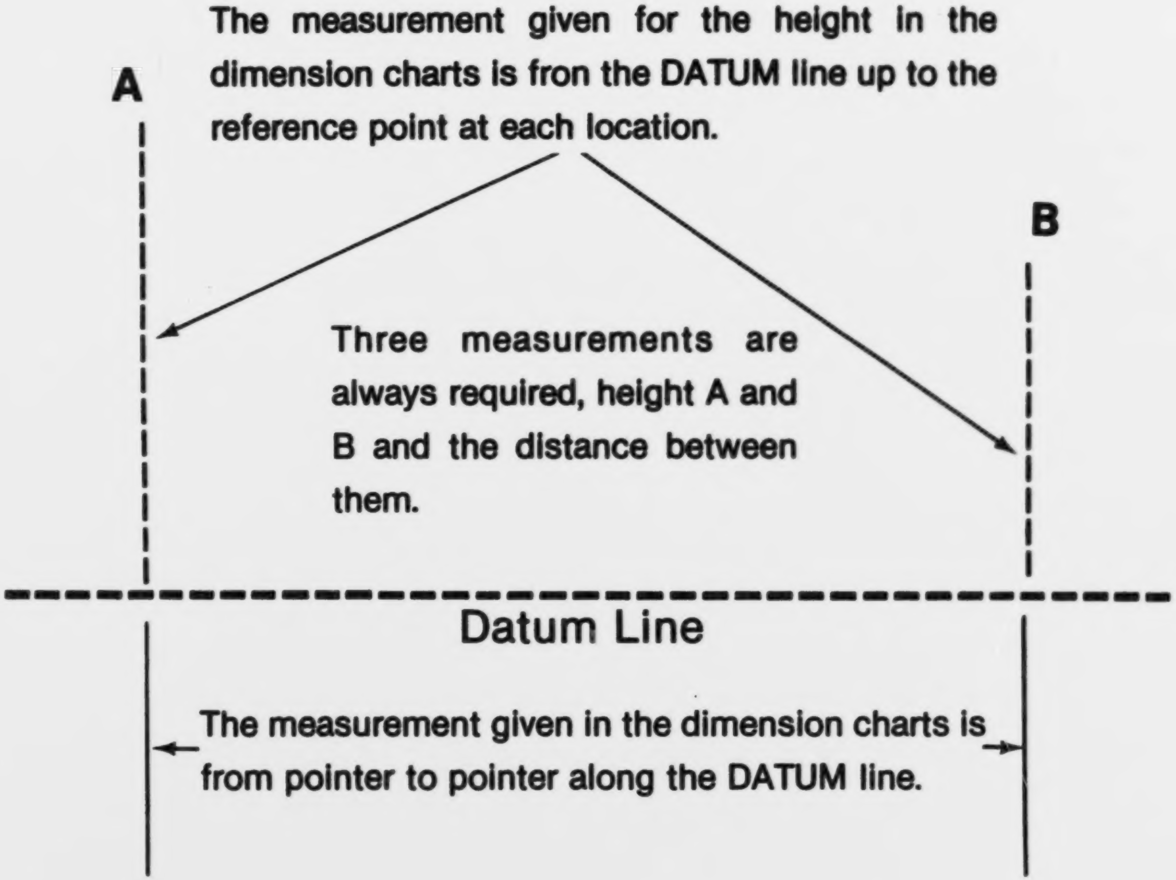
B

Length of bar set for distance between A & B

Datum Line

Tram Gauge

Tram Gauge Specifications

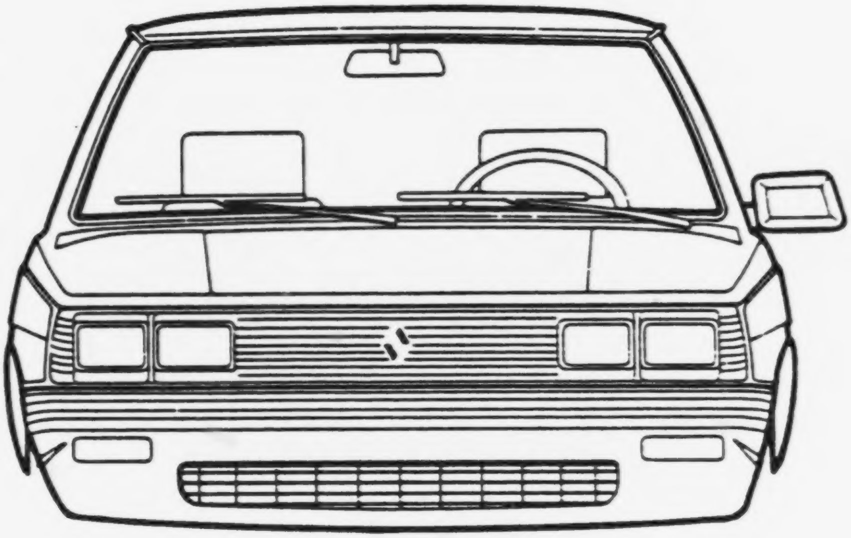


The measurement given for the height in the dimension charts is fron the DATUM line up to the reference point at each location.

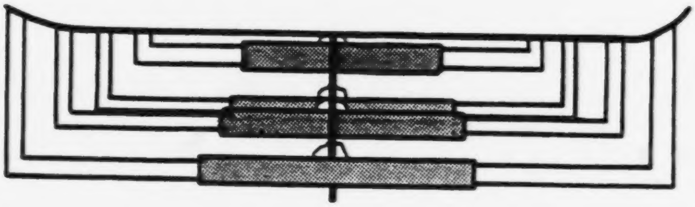
Three measurements are always required, height A and B and the distance between them.

The measurement given in the dimension charts is from pointer to pointer along the DATUM line.

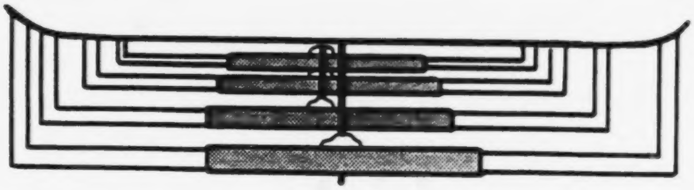
Centering Gauge Alignments



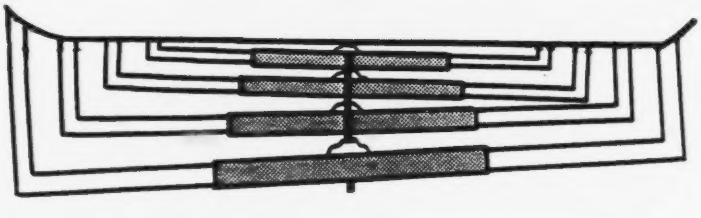
Types of Damage



SAG



SIDESWAY



TWIST

Courtesy of Blackhawk Automotive, Inc.

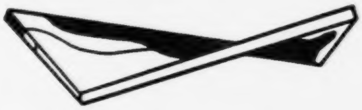
MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT V: TYPES OF DAMAGE AND MEASURING SYSTEMS

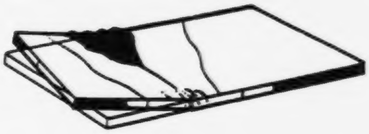
UNIT V TEST

I. Match the following with the correct letter from the right column. Each choice may be used more than once.

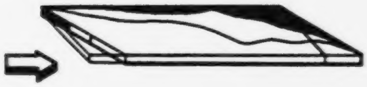
_____1.



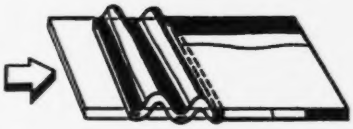
_____2.



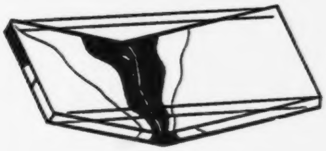
_____3.



_____4.



_____5.



_____6. Identified by centerline measurement

_____7. Identified by length measurement

_____8. Identified by datum height in center section

_____9. Identified by diagonal measurements

_____10. Identified by datum height in cowl area

_____11. Seldom occurs in unibody

_____12. Must be carefully analyzed if present

A. Mash damage

B. Sidesway damage

C. Sag damage

D. Diamond damage

E. Twist damage

AB. Combination damage

II. Match the terms in the left column with the letter of the correct illustrations in the right column. The letters for the illustrations in the right column may be used more than once.

_____13. Laser system

_____14. Mechanical universal

_____15. Tram/tracking gauge

_____16. Dedicated bench

_____17. Self-centering datum gauge

_____18. Uses precision bridge and pointers

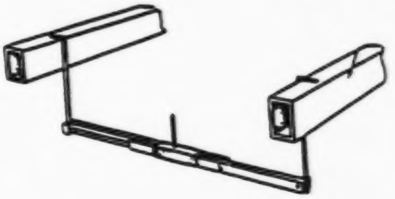
_____19. Can measure over obstructions

_____20. Uses fixtures that match exact vehicle

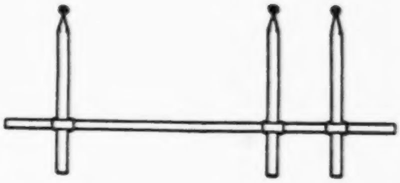
_____21. Uses optical targets

_____22. At least four must be hung from vehicle

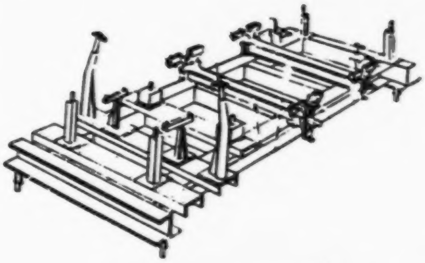
A.



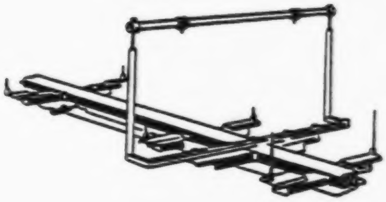
B.



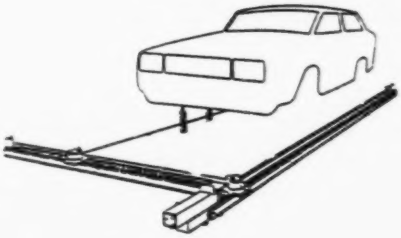
C.



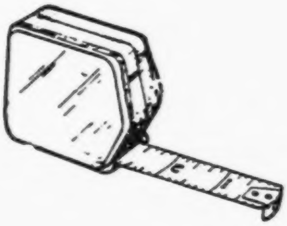
D.



E.

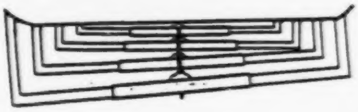


AB.

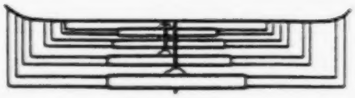


III. Identify the following types of damage by matching the illustration at the left with the terms in the right column

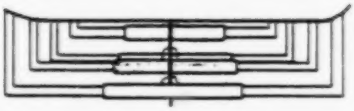
_____23.



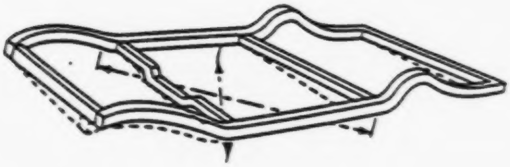
_____24.



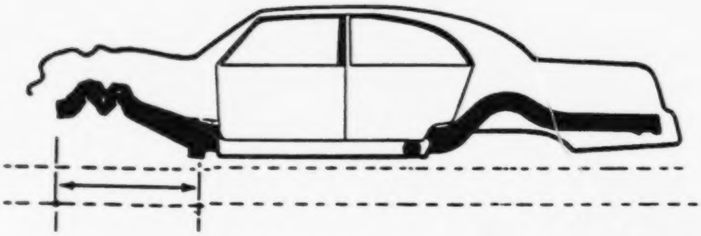
_____25.



_____26.



_____27.



A. Sidesway

B. Sag

C. Mash

D. Twist

E. Diamond

AB. Combination

(NOTE: Completion of this unit test is the evaluation for Competency X3 "lentify the 5 types of damage." Of the 27 questions, a score of _____ correct = 3, _____ correct = 2, _____ correct = 1, _____ correct or below, student should retake this test.)

ANSWERS TO UNIT V TEST

1. E
2. B
3. D
4. A
5. C
6. B
7. A
8. E
9. D
10. C
11. D
12. AB

13. E
14. D
15. B
16. C
17. A
18. D
19. B
20. C
21. E
22. A

23. D
24. A
25. B
26. E
27. C

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT VI: ANALYZING DAMAGE

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to prepare a vehicle for damage analysis and analyze frame damage using different measuring systems. Mastery will be evidenced through demonstration.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Apply principles of supporting vehicle for datum/tram gauge analysis (Competencies X6 and X7, Job Sheet #1)

II. Apply principles of supporting vehicle for universal or dedicated analysis (Competencies X8 and X9, Job Sheet #1)

III. Apply principles of attaching vehicle to bench (Competencies X8 and X9, Job Sheet #1)

IV. Apply considerations in removing mechanical components (Competencies X8 and X9, Job Sheet #1)

V. Apply safety procedures (Competencies X6-X9, Job Sheets #1-#6)

VI. Identify considerations for type of measuring system (Competencies X6-X9, Job Sheet #1)

VII. Apply principles of the dedicated bench (Competency X9, Job Sheet #6

Lesson 2:

I. Identify use of specification manuals (Competency X4, Assignment Sheet #1)

II. Demonstrate the ability to:

   a. Use specification manuals (Competency X4, Assignment Sheet #1)

   b. Analyze frame damage using the self-centering datum gauge (Competency X6, Job Sheet #2)

   c. Analyze frame damage using the tram/tracking gauge (Competency X7, Job Sheet #3)

   d. Analyze frame damage using the tape measure (Competency X7, Job Sheet #4)

   e. Analyze frame damage using universal measuring system (Competency X8, Job Sheet #5)

   f. Analyze frame damage using dedicated measuring system (Competency X9, Job Sheet #6)

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT VI: ANALYZING DAMAGE

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

1. Lesson 1: Preparing vehicle for analysis

   a. Information outline

   b. Handouts

      HO#1: Dedicated fixtures

2. Lesson 2: Use specification manuals to gauge and analyze damage

   a. Information outline

   b. Handouts

      HO#1: Vehicle specifications
      HO#2: Vehicle specifications
      HO#3: Vehicle specifications

   c. Assignment Sheet # 1, Use and interpret specification manuals

   d. Job sheets

      JS#1: Prepare vehicle for analysis
      JS#2: Gauge and analyze damage using self-centering datum gauges
      JS#3: Gauge and analyze damage using the tram gauge
      JS#4: Gauge and analyze damage using steel tape measure
      JS#5: Gauge and analyze damage using universal measuring system
      JS#6: Gauge and analyze damage using dedicated measuring systems

NOTES TO THE INSTRUCTOR

A. Setting up Assignment Sheet #1, Lesson Two:

1. Vehicle specifications for at least two vehicles available in your shop should be photocopied. Using "white-out" fluid, some datum distances and some point-to-point distances should be blotted out.

2. Clearly indicate to students that the blotted out distances are the ones they are to determine in the shop by identifying the control points shown in the specifications and taking the measurements.

3. A total of 10 distances should requested. At least five of these distances should be datum distances, and at least five distances should be on a unibody vehicle.

4. Students may work in teams or alone.

5. Instructor must safely prepare vehicles for measurements. One of the vehicles should be of present-day unibody construction.

6. Instructor must ascertain measurements, because specifications may be misprinted, or vehicle could be damaged. (Undamaged vehicle can be used).

B. There is no test for this material. It is felt that performing the job sheets is enough.

C. The job sheet for analyzing damage with the steel tape could be evaluated independently, or as part of the procedure for using the tram gauge. Competency W7 assumes that the tape measure will be used, when possible, while analyzing damage with the tram gauge.

REFERENCES USED IN WRITING THIS UNIT

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9. Mitchell Information Services, Inc. *Collision Estimating Guide Domestic, General Motors.* Mitchell Information Services. San Diego, CA. August, 1986.

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MODULE: FRAME AND UNIBODY CONSTRUCTION AND REPAIR

UNIT VI: ANALYZING DAMAGE

LESSON 1: PREPARING VEHICLE FOR ANALYSIS

I. **Principles of supporting vehicle for tram gauge, datum gauge, or tape-measure analysis**

(NOTE: See Module 1, Unit V for details on lifting, jacking, and supporting vehicles.)

A. For supporting in torque box areas

1. Use pinchweld clamps, support tubes and support stands, for unitized vehicles with pinchwelds. (See Module 1, Unit V)

2. Use support stands under the torque box areas for frame-body vehicles. (See Module 1, Unit V)

B. For supporting under load-bearing areas of suspension, use support stands according to vehicle manufacturer's recommendations for both frame-body and unitized construction.

C. Support the vehicle in such a way that you can make measurements from an undamaged area to a damaged area.

D. Support the vehicle in such a way that it is as level as possible. Assuming the shop floor is level, the supports should be placed such that the imaginary datum plane is as close as is practical to being parallel to the floor.

II. **Principles of supporting vehicle for using universal or dedicated measuring systems**

A. Both laser and mechanical systems may use frame stands in the same manner as used for datum and tram gauge analysis. However, both systems are generally used with unitized vehicles and a universal bench (or a dedicated bench used as a universal bench).

B. In using either the universal or the dedicated bench, the vehicle is supported by being properly attached to the pinchweld clamps and fixtures of the bench.

III. **Basic procedure for attaching unibody vehicle to universal bench or dedicated bench**

A. A portable lift may be used. (Consult portable lift manufacturer's recommended procedure).

B. If a lift is not available, vehicle must be supported by pinchweld clamps, support tubes and support stands, as in Module 1, Unit V. If the vehicle does not have pinchwelds, then consult vehicle manufacturer's specifications for proper lifting and supporting.

C. Procedure for using pinch weld clamps, support tubes and support stands to position vehicle on bench

1. After vehicle is supported on pinchweld clamps and support tubes, slide bench under vehicle.

2. Starting at the least-damaged end, raise bench using bench's jacking pad until fixtures are in position.

3. Attach the fixtures.

4. Raise bench higher until support stands can be removed.

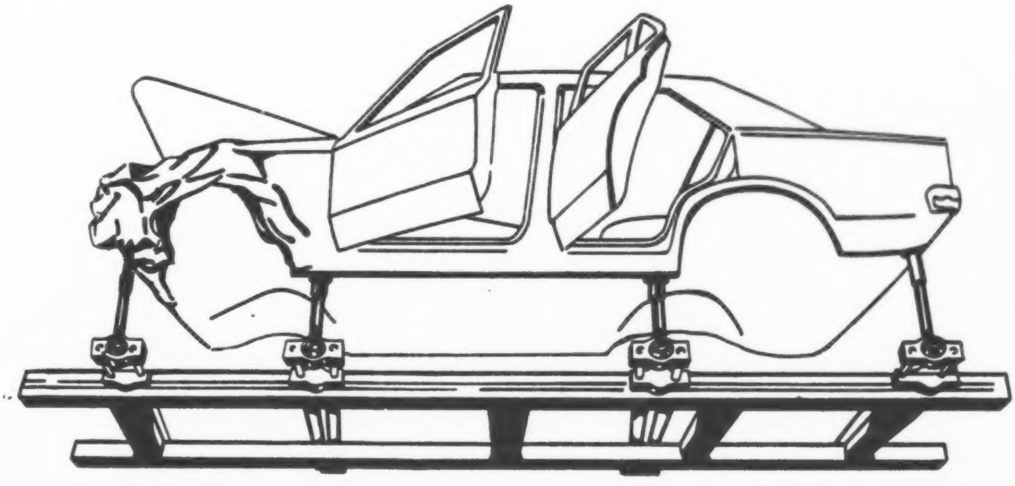
5. Lower bench to floor.

6. Repeat procedure for other end of vehicle, gaining a total of at least three attachment points).

7. Remove support tubes and pinchweld clamps, then install bench's built-in pinchweld clamps.

8. If bench does not have a jacking pad, then vehicle must be supported by jacks on the ends of each support tube so that vehicle can be lowered onto fixtures.

   (NOTE: Many benches have their own special procedures. Consult bench manufacturer's recommended procedures.)



Courtesy of Chart Industries, Ltd.

D. Rough pulling

1. In supporting a vehicle on a bench, it is sometimes necessary to "rough pull" components.

2. For the universal bench, at least three of the four universal fixtures in the torque box areas must line up.

3. For the dedicated bench any three fixtures may be used but more that three attachments are preferred.

   (**Caution:** *If only three fixtures are attached, they should be anchoring fixtures near the torque box areas).*

4. If three points are not gained, plan a pulling operation or operations that will provide three control points.

5. After each rough pull, the repairman should stop and remove the pull apparatus. Once rough pulling procedure has provided three fixture points, stop the pull and remove the pulling apparatus.

   (NOTE: Pulling procedures are covered in Unit VII and Unit VIII)

IV. Removal of mechanical components

A. In deciding whether to remove mechanical components there are two things to consider:

   1. The purpose of making measurements.

   2. The location of damage.

B. Mechanical components are not removed until a thorough analysis of the damage has established that mechanical component removal will be necessary.

C. If a vehicle is to be placed on a bench and the drive train is to be removed, then it must be removed prior to placing the vehicle on the bench.

V. Safety procedures in preparing vehicle for measurement

A. Mask broken glass with tape and label "danger."

B. Grind down sharp metal edges.

C. Clean up all leaking fluids.

D. Remove the fuel tank.

E. Disconnect the battery.

F. Keep your eyes open and alert for potential safety hazards at all times.

G. Follow equipment and vehicle manufacturer's guidelines.

VI. Deciding which measuring system to use

A. The purpose of the analysis determines the system used

   1. If measurements are being taken for estimating purposes, generally a steel tape measure is all that will be used, along with equipment for suspension quick-checks.

2. If measurements are being taken to determine exact extent of damage to determine method of repair, then self-centering gauges along with a tram gauge and a steel tape measure are usually used.

B. Universal and dedicated systems are used to help plan repairs and to monitor the progress of repair procedures. They are only used after another measuring process has determined that there is damage and that a universal or dedicated bench will be used for repair.

C. If it has been established that damage is present and repairs will be made, the following considerations apply to deciding which system to use during the repair procedure (assuming all systems are available).

1. For frame-body vehicles

   a. Generally the tram gauge and centering gauge will be used.

   b. It may be possible to use universal systems, depending on vehicle and damage.

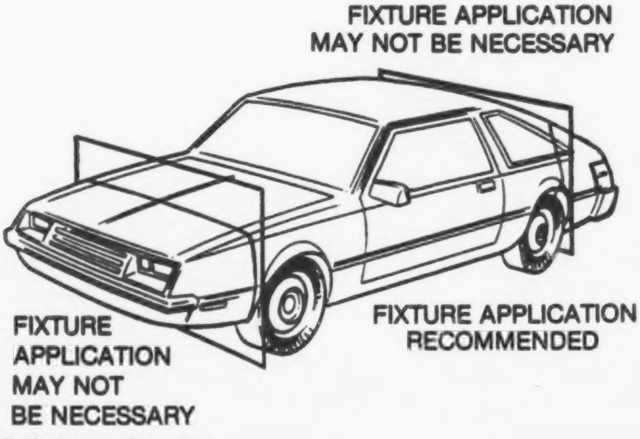
2. For unibody vehicles

   a. Extent of damage will determine system used.

   b. If damage is ahead of front strut towers or behind rear strut/shock towers, then tram and centering gauges may be used, although universal system may be more efficient.

   c. If damage extends into or behind front strut towers or into and ahead of rear strut/shock towers then universal or dedicated bench systems are usually used. (If dedicated bench and correct fixtures are available, then dedicated bench is usually used). (FIG. 1-1)

FIGURE 1-1



Courtesy of Blackhawk Automotive, Inc.

VII. Principles of using the dedicated bench

A. The dedicated bench is both a measuring system and a component of a repair system.

B. In using the bench, the fixtures provide the means for making measurements.

C. Use fixtures which will require only as much mechanical component removal as is necessary for repairs.

D. In setting up a dedicated bench, the fixtures are placed at the proper locations using a fixture diagram, which shows the fixture placement for each type or family of cars.

E. The fixture diagram does not provide exactly the same information as a vehicle specification sheet, but it provides all the information needed to make critical underbody and underhood repairs.

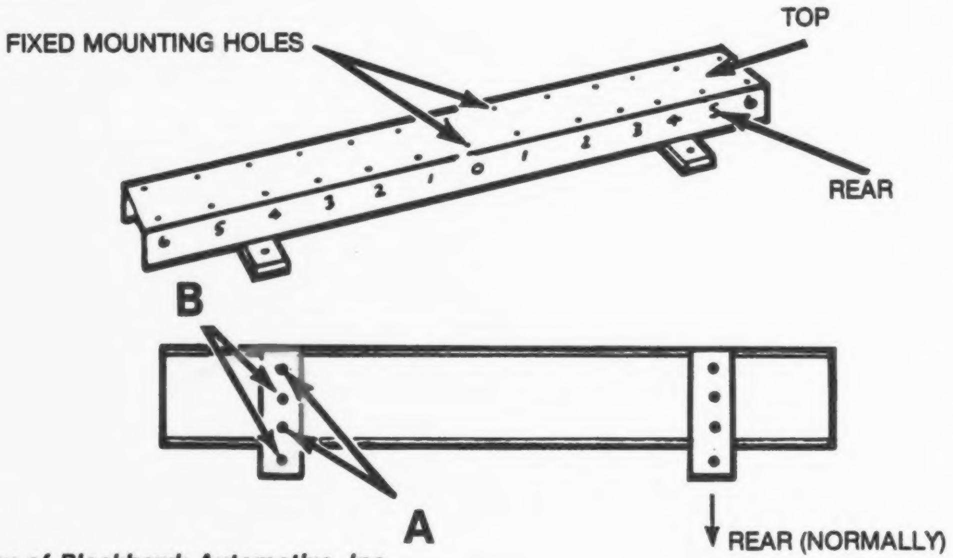
(NOTE: In the case of upper-body damage, vehicle specifications will still be needed to complete repairs with the dedicated bench).

F. Fixtures are labeled on the fixture diagram to indicate how they are used according to whether or not mechanical components have been removed.

G. The fixture diagram specifies three important elements. (Figure 1-2.)

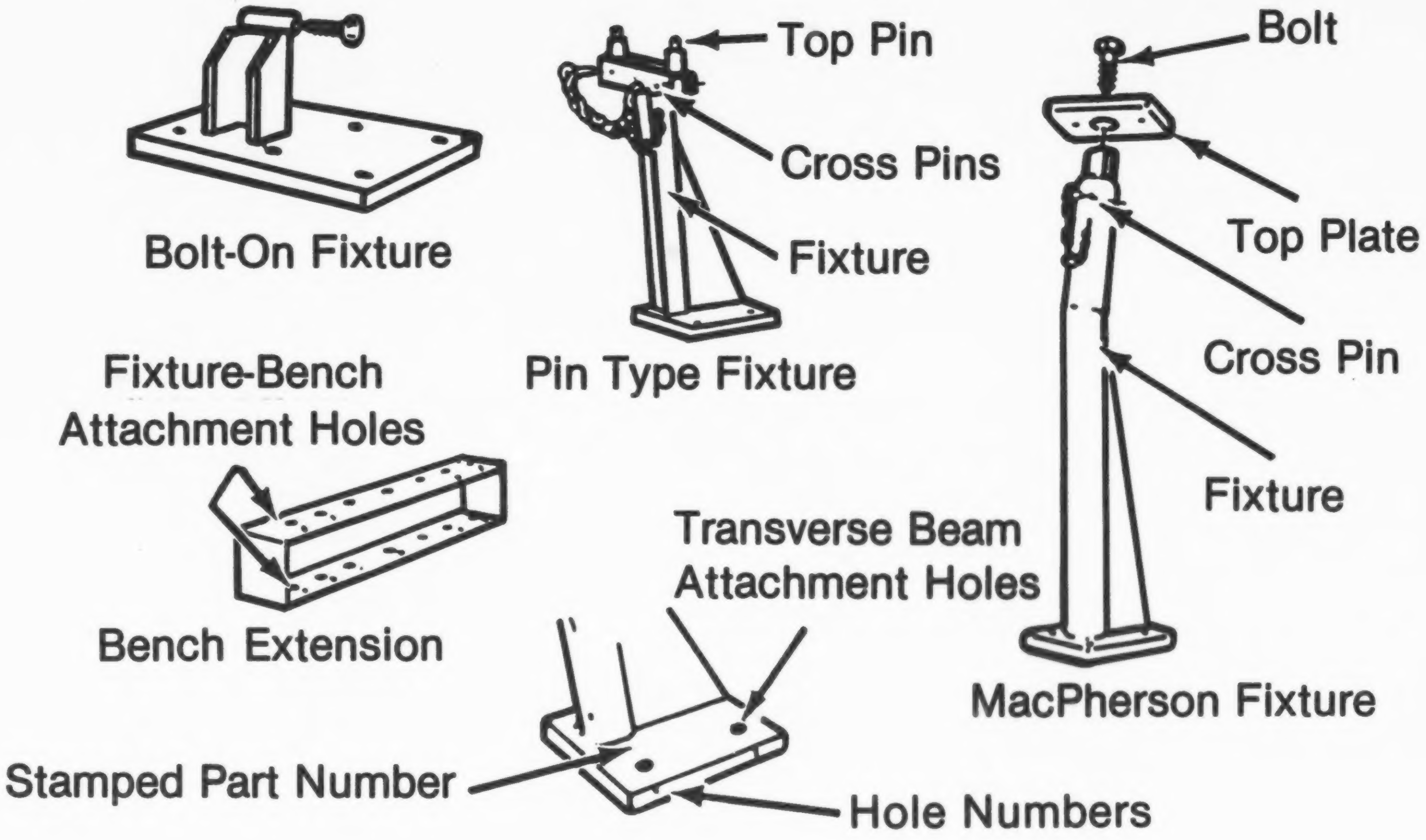
1. Exactly where the transverse beams are located
2. Exactly where the fixtures are located
3. Which fixtures are used for each vehicle

FIGURE 1-2



Courtesy of Blackhawk Automotive, Inc.

Fixtures and Bench Extensions


Bolt-On Fixture
Top Pin
Cross Pins
Fixture
Pin Type Fixture
Bolt
Top Plate
Cross Pin
Fixture
MacPherson Fixture
Fixture-Bench Attachment Holes
Bench Extension
Transverse Beam Attachment Holes
Stamped Part Number
Hole Numbers

Courtesy of Blackhawk Automotive, Inc.

HO 1

MODULE: FRAME AND UNIBODY CONSTRUCTION AND REPAIR

UNIT VI: ANALYZING DAMAGE

LESSON TWO: USE SPECIFICATION MANUALS TO ANALYZE DAMAGE

I. **Using specification manuals**

A. To analyze damage, vehicle specifications are used to compare true dimensions with actual dimensions.

(Note: In some cases an identical but undamaged vehicle can be used as a reference.)

B. Specification manuals are available from different sources. The specification manual selected should be one that best matches the specifications needed for the particular measuring system to be employed.

C. Specification manuals give measurements to establish datum line, center line, datum distance, and point-to-point distances in millimeters and fractions.

D. Datum-line distances are given from control points and reference points to datum line and are usually labeled "side view."

E. Center-line distances are usually given by showing the distances between symmetrically opposed control points or reference points, usually labeled "bottom view" or "underbody view." The center line is established by dividing this distance in half. Occasionally, the distance from the center line to each opposing control point is given, in which case the distances must be added together to find the datum distance between the two control points.

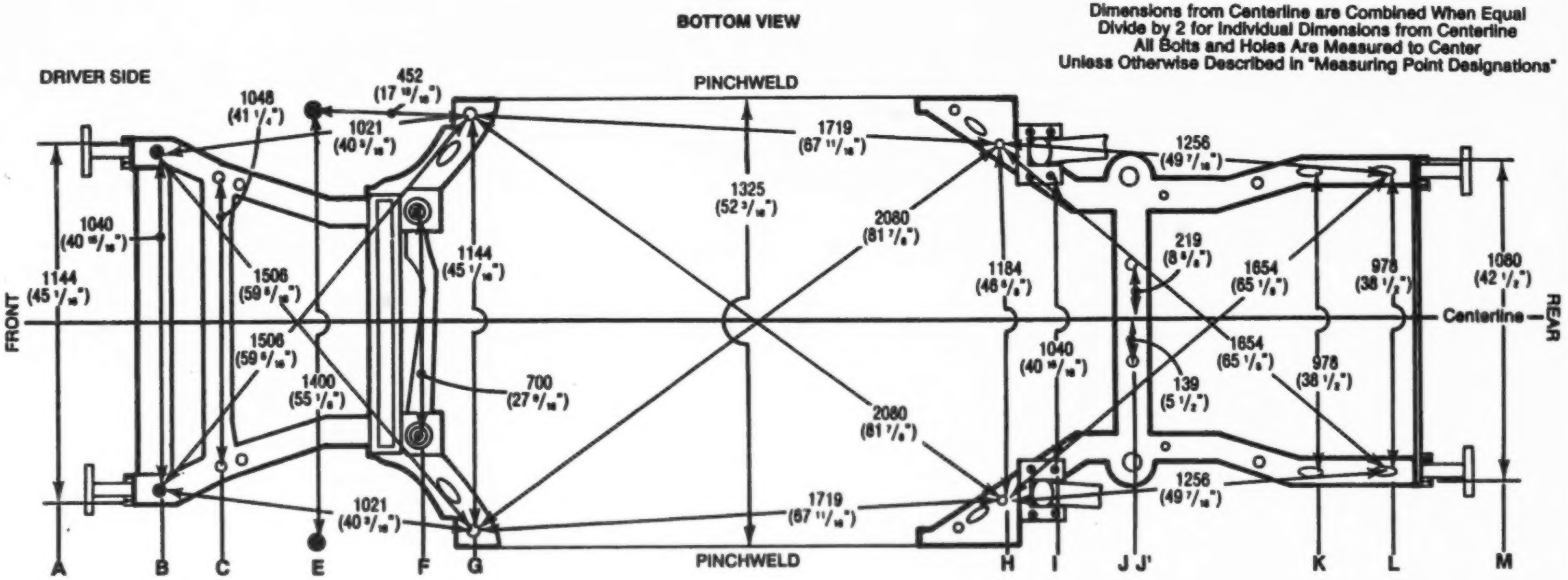
(Note: If distances between non-symmetrical control points are given for establishing center line, they will be indicated as such)

F. Datum distances are given between control points and reference points as located on datum plane and are usually given in the same view, providing center line information.

G. Point-to-point distances may be given for significant point-to-point measurements, usually including underhood measurements and sometimes including passenger compartment and luggage compartment measurements. They are usually labeled "upperbody dimensions."

Bottom View

Dimensions from Centerline are Combined When Equal
Divide by 2 for Individual Dimensions from Centerline
All Bolts and Holes Are Measured to Center
Unless Otherwise Described in "Measuring Point Designations"


BOTTOM VIEW
DRIVER SIDE
FRONT
REAR
Centerline
PINCHWELD
PINCHWELD
1048 (41 1/4")
452 (17 13/16")
1021 (40 3/16")
1021 (40 3/16")
1040 (40 15/16")
1144 (45 1/16")
1506 (59 5/16")
1506 (59 5/16")
1400 (55 1/8")
700 (27 9/16")
1144 (45 1/16")
1325 (52 3/16")
1719 (67 11/16")
1719 (67 11/16")
2080 (81 7/8")
2080 (81 7/8")
1184 (46 5/8")
1040 (40 15/16")
1256 (49 7/16")
1256 (49 7/16")
219 (8 5/8")
139 (5 1/2")
1654 (65 1/8")
1654 (65 1/8")
978 (38 1/2")
978 (38 1/2")
1080 (42 1/2")
A
B
C
E
F
G
H
I
J
J'
K
L
M

HO 1

S-FRAME - 109

I-FRAME - 227

1986-87 Buick Century 2-Door Coupe

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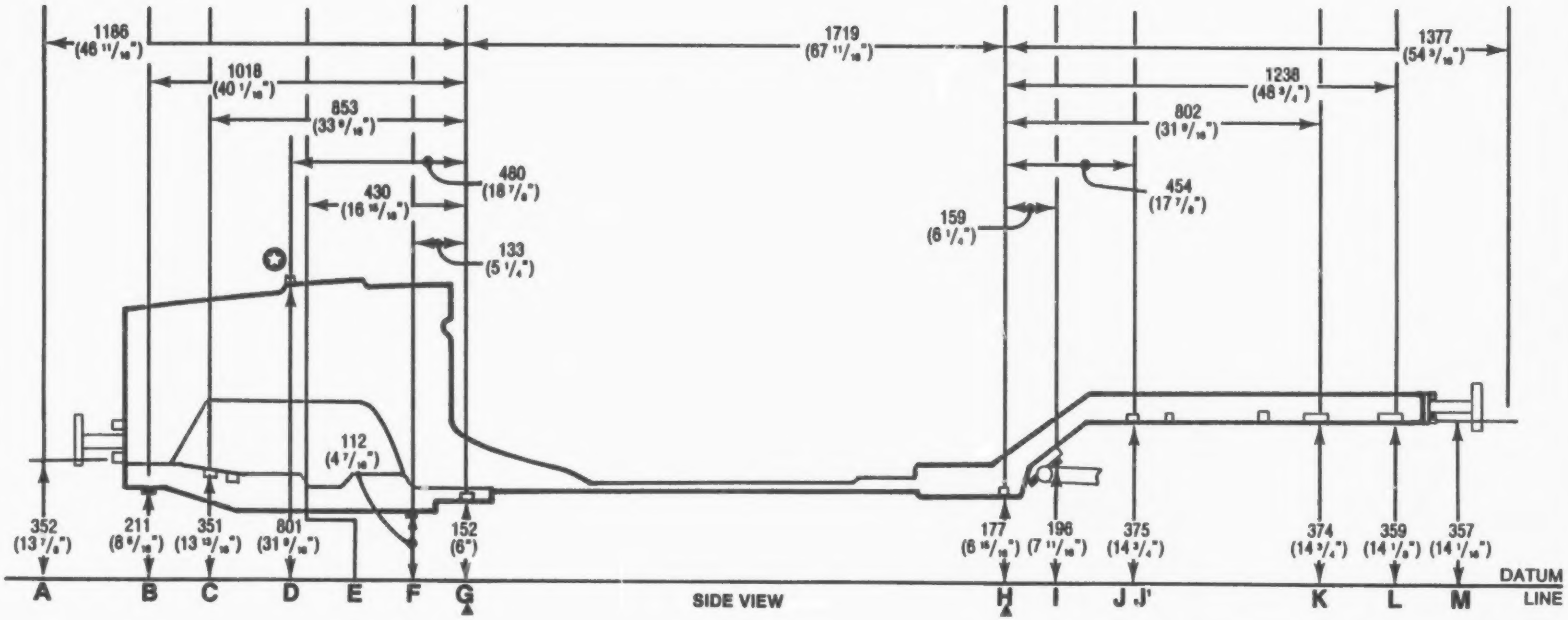
Side View


1186
(46 11/16")
1018
(40 1/16")
853
(33 9/16")
480
(18 7/8")
430
(16 15/16")
133
(5 1/4")
1719
(67 11/16")
1377
(54 3/16")
1238
(48 3/4")
802
(31 9/16")
454
(17 7/8")
159
(6 1/4")
112
(4 7/16")
352
(13 7/8")
211
(8 5/16")
351
(13 13/16")
801
(31 9/16")
152
(6")
177
(6 15/16")
196
(7 11/16")
375
(14 3/4")
374
(14 3/4")
359
(14 1/8")
357
(14 1/16")
A
B
C
D
E
F
G
SIDE VIEW
H
I
J J'
K
L
M
DATUM
LINE

HO 2

S-FRAME - 111

I-FRAME - 229

1986-87 Buick Century 2-Door Coupe

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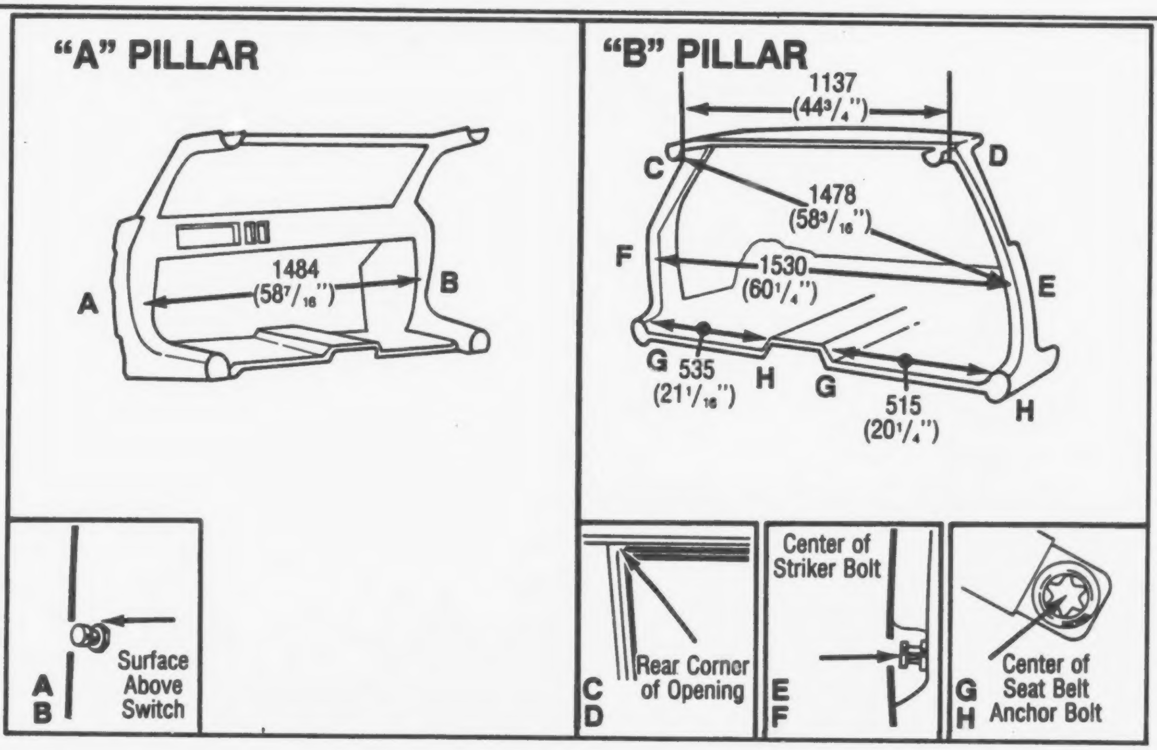
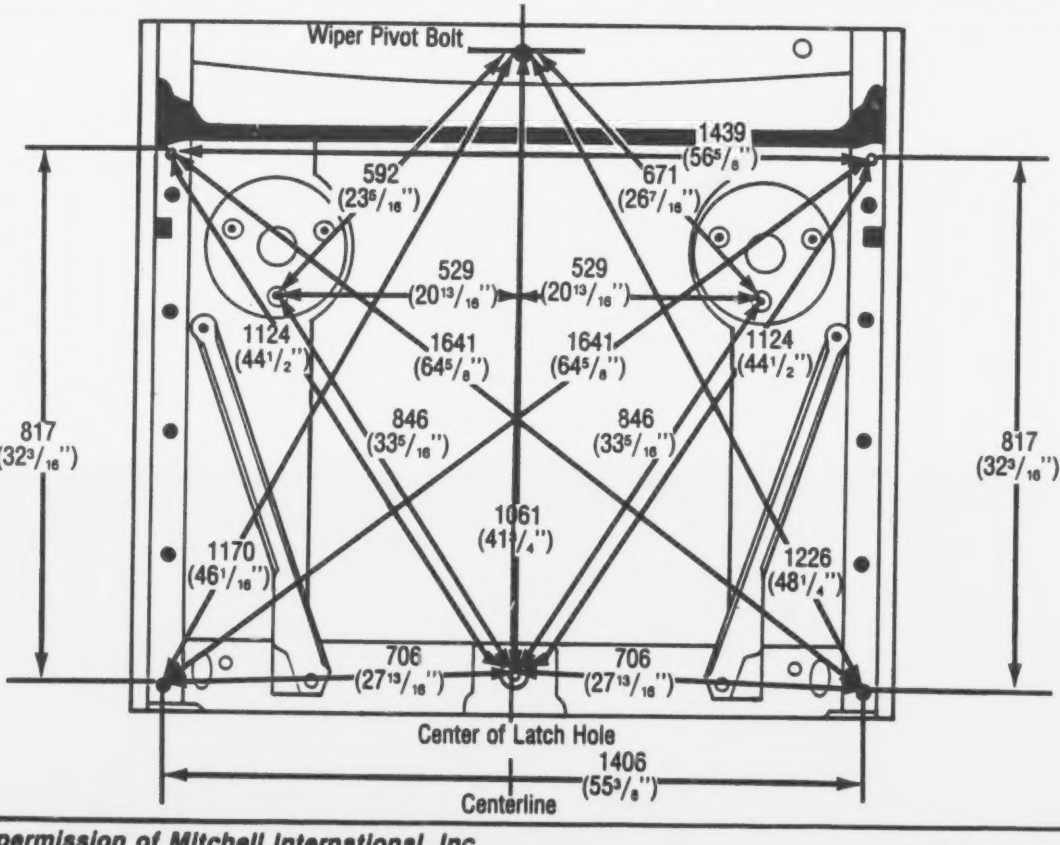
Point-to-Point Distances


"A" PILLAR
1484
(58 7/16")
A
B
A
B
Surface Above Switch
"B" PILLAR
1137
(44 3/4")
C
D
1478
(58 3/16")
F
1530
(60 1/4")
E
G
535
(21 1/16")
H
G
515
(20 1/4")
H
C
D
Rear Corner of Opening
Center of Striker Bolt
E
F
G
H
Center of Seat Belt Anchor Bolt


Wiper Pivot Bolt
1439
(56 5/8")
592
(23 5/16")
671
(26 7/16")
529
(20 13/16")
529
(20 13/16")
1124
(44 1/2")
1641
(64 5/8")
1641
(64 5/8")
1124
(44 1/2")
817
(32 3/16")
846
(33 5/16")
846
(33 5/16")
817
(32 3/16")
1061
(41 3/4")
1170
(46 1/16")
1226
(48 1/4")
706
(27 13/16")
706
(27 13/16")
Center of Latch Hole
1406
(55 3/8")
Centerline

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UNIT VI

ASSIGNMENT SHEET #1, LESSON 2

USE AND INTERPRET SPECIFICATION MANUALS

I. **Directions**

A. Your instructor will provide vehicle specifications for two vehicles available in your shop.

B. Vehicle specifications given show all datum heights.

C. Vehicle control-point measurements for datum distance and point-to-point distances are given, but distances have been blotted out.

D. Using tram gauge, take measurements for missing distances indicated on assignment sheet and record measurements on assignment sheet.

(NOTE: This assignment sheet will be the evaluation for Competency X4 "Use and interpret specification manuals.")

UNIT VI

JOB SHEET #1, LESSON TWO

PREPARE VEHICLE FOR ANALYSIS

Equipment needed:

Vehicle
Proper jacking and/or lifting equipment
Proper supporting equipment
Tape measure
Tools which may be needed to grind down sharp edges, remove battery and fuel tank, or perform other safety requirements

(NOTE: This Job Sheet is for evaluation purposes only. It is not an exact steps of procedure.)

Procedure:	**Evaluation:** 3	2	1	N
1. Determine and perform safety measures required.				
2. Determine method of jacking and supporting vehicle at sufficient height to establish datum line.				
3. Raise vehicle for supports.				
4. Install supports.				
5. Determine and perform any additional safety measures.				
Average of above evaluations*				

*This average will become a part of the evaluation on Job sheets #2 through #6

UNIT VI

JOB SHEET #2, LESSON TWO

GAUGE AND ANALYZE DAMAGE USING SELF-CENTERING DATUM GAUGES

Equipment

Vehicle
At least four self-centering datum gauges
Specification guide for vehicle
Proper lifting and supporting equipment, including equipment manufacturer's recommendations.
Tape measure
Tools needed to perform safety measures, such as grinding metal, removing battery and fuel tank, etc.

Procedure:

	Evaluation: 3	2	1	N
1. Prepare vehicle for gauging by performing Job Sheet #1.	___	___	___	___
2. Clean and calibrate gauges.	___	___	___	___
3. Install at least four gauges, one at or near each reference area.	___	___	___	___
4. Check for damage revealed by datum line.	___	___	___	___

(Note: Sight six to eight feet from vehicle, while standing on vehicle centerline. Scan crossbars with both eyes open to check for datum alignment. Scan sighting pins with one eye closed for centerline).

	3	2	1	N
5. Check for damage revealed by center line.	___	___	___	___
Average of above evaluations*	___	___	___	___

*This average is the evaluation for competency X6, "Analyze damage using self-centering datum gauge"

UNIT VI

JOB SHEET #3, LESSON TWO

GAUGE AND ANALYZE DAMAGE USING THE TRAM GAUGE

Equipment

Vehicle
Tram gauge
Specification guide for vehicle
Proper lifting and proper supporting equipment, including manufacturer's recommendations for operation
Tape measure
Tools needed to perform safety measures, such as grinding metal, removing battery and fuel tank, etc.

Procedure:

Evaluation:

	3	**2**	**1**	**N**
1. Prepare vehicle for gauging by performing Job Sheet #1.	___	___	___	___
2. Clean and calibrate tram gauge.	___	___	___	___
3. Take and record all datum distances as given in vehicle specifications.	___	___	___	___
4. Analyze readings taken and determine damage revealed.	___	___	___	___
Average of above evaluations*	___	___	___	___

*This average is one-half the evaluation for competency X7, "Analyze damage using tram gauge and tape measure." The other half is from Job Sheet #4.

UNIT VI

JOB SHEET #4, LESSON TWO

GAUGE AND ANALYZE DAMAGE USING STEEL TAPE MEASURE

Equipment

Vehicle
Specification guide for vehicle
Proper lifting and proper supporting equipment, including manufacturer's recommendations for operation
Steel tape measure
Tools needed to perform safety measures, such as grinding metal, removing battery and fuel tank, etc.

Procedure:

	Evaluation: 3	2	1	N
1. Prepare vehicle for gauging by performing Job Sheet #1.	___	___	___	___
2. Determine which point-to-point measurements can be accurately taken with tape measure, measure and record same.	___	___	___	___
3. Determine what datum line measurements can be taken accurately with tape measure, measure and record same.	___	___	___	___
4. Using readings taken, analyze damage revealed.	___	___	___	___
Average of above evaluations*	___	___	___	___

*This average is one-half the evaluation for competency X7, "Analyze damage using tram gauge and tape measure." The other half is from Job Sheet #3.

UNIT VI

JOB SHEET #5, LESSON TWO

GAUGE AND ANALYZE DAMAGE USING UNIVERSAL MEASURING SYSTEM

Equipment

Vehicle
Universal measuring system
Specification guide for vehicle
Proper lifting and supporting equipment, including manufacturer's recommendations for operation
Tape measure
Tools needed to perform safety measures, such as grinding metal, removing battery and fuel tank, etc.

Procedure:

Evaluation:
3 2 1 N

(Note: Instructor will demonstrate proper procedure according to equipment available)

1. Prepare vehicle for gauging by performing Job Sheet #1. ___ ___ ___ ___
2. If bench is used, attach vehicle to bench ___ ___ ___ ___
3. Attach measurement bridges or set up laser equipment, whichever is used. ___ ___ ___ ___
4. Attach mechanical pointers or laser optics, whichever is used. ___ ___ ___ ___
5. Analyze damage revealed by mechanical pointers or laser-optics, whichever is used. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

*This average is the evaluation for competency X8, "Analyze damage using universal measuring systems."

UNIT VI

JOB SHEET #6, LESSON TWO

GAUGE AND ANALYZE DAMAGE USING DEDICATED MEASURING SYSTEM

Equipment:

Vehicle
Dedicated measuring system
Specification guide for vehicle
Proper lifting and supporting equipment, including manufacturer's recommendations for operation
Tools needed to perform safety measures, such as grinding metal, removing battery and fuel tank, etc.

Procedure:	**Evaluation:** 3	2	1	N
1. Prepare vehicle for gauging by performing Job Sheet #1.	___	___	___	___
2. Raise bench and attach fixtures to vehicle, or lower vehicle onto bench and attach fixtures.	___	___	___	___
3. Attach additional fixtures to bench as required.	___	___	___	___
4. Analyze damage revealed by alignment of fixtures with control points.	___	___	___	___
Average of above evaluations*	___	___	___	___

*This average is the evaluation for competency X9, "Analyze damage using dedicated measuring systems"

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT VII: FRAME REPAIR TECHNIQUES AND EQUIPMENT

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to describe and use frame repair techniques and equipment. Mastery will be evidenced through demonstration and by scoring __________percent on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Match basic terms with their definitions or illustrations (Competency Y1, Unit VII test)

II. Identify pulling and anchoring equipment (Competency Y1, Unit VII test)

III. Identify frame-straightening units (Competency Y1, Unit VII test)

IV. Identify basic pulls and pushes (Competency Y1, Unit VII test)

V. Identify basic frame repair guidelines (Competency Y1, Unit VII test)

VI. Identify the cone concept (Competency Y1, Unit VII test)

VII. Identify the partial replacement of frame sections (Competency Y1, Unit VII test)

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT VII: FRAME REPAIR TECHNIQUES AND EQUIPMENT

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. References

D. Lesson plans

   1. Lesson 1: Frame repair concepts and equipment

      a. Information outline

      b. Transparency masters

         TM#1: Portable frame units
         TM#2: Stationary frame rack
         TM#3: Floor anchoring grid
         TM#4: Dedicated bench

E. Unit test

F. Answers to unit test

REFERENCES USED IN WRITING THIS UNIT

1. Blackhawk Automotive. *New Science of Unibody Repair.* Blackhawk Automotive. Milwaukee, WI. 1984.

2. Chart Industries, Ltd. *Chart's Unibody Repair Program.* Chart Industries, Ltd. Pickering, Ontario. N.D.

3. Crouse, William, and Anglin, Donald. *Automotive Body Repair and Refinishing.* Second edition. McGraw-Hill. New York, NY. 1986.

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5. Hardin, Gil. *Measuring and Fixturing Techniques.* The Media Center, State Fair Community College. Sedalia, MO. 1983.

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7. Inter-Industry Conference on Auto Collision Repair. Unibody Auto Collision Repair Training Program. *Measuring and Fixturing Systems.* D.I.A. Communications. Des Plains, IL. 1981.

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MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT VII: FRAME REPAIR TECHNIQUES AND EQUIPMENT

LESSON 1: FRAME REPAIR TECHNIQUES AND EQUIPMENT

I. **Terms and definitions**

A. Anchoring grid -- A configuration of slotted rails built into the floor of a body shop to provide anchoring and pulling points.

B. Combination damage -- Damage to a vehicle which includes two or more of five basic types of frame damage.

C. Cone concept -- A method of visualizing the extent of collision damage on unibody vehicles in which the point of initial impact is thought of as the point of a cone, with resulting damage spreading over an ever-widening area.

D. Fishplating -- Strengthening a conventional frame by welding a plate or rail to a frame member.

E. Floor anchor -- Any stationary anchoring and pulling system which is built into the floor of a body shop. It may employ pot hole anchors and/or an anchoring grid.

F. Frame clamp -- A portable anchoring system which can anchor many unibody and some perimeter frame vehicles by attaching to the pinchwelds.

G. Hydraulic pump -- A pump using hydraulic fluid to multiply force.

H. Hydraulic ram -- A hydraulic jack, usually with a remote reservoir and pump, that is designed for use in frame-straightening systems.

I. Multiple-pull system -- Any frame-straightening unit designed to simultaneously make pulls in more than one direction.

J. Overpulling -- Pulling a damaged frame component beyond its original dimensions.

K. Portable unit -- Any frame-straightening unit that can be moved from vehicle damage point to damage point and from vehicle to vehicle.

L. Primary damage -- Damage to components as a direct result of collision impact.

M. Pull plate -- A metal plate temporarily welded to a frame component to provide a pulling point where none exists.

N. Secondary damage -- Collision damage to vehicle components beyond the primary impact area and resulting from the primary damage.

O. Self-tightening clamp -- Any of a variety of clamps in which the force of the pulling procedure provides the force for tightening the clamp.

P. Single-pull system -- Any frame-straightening unit designed to make only one single-direction pull.

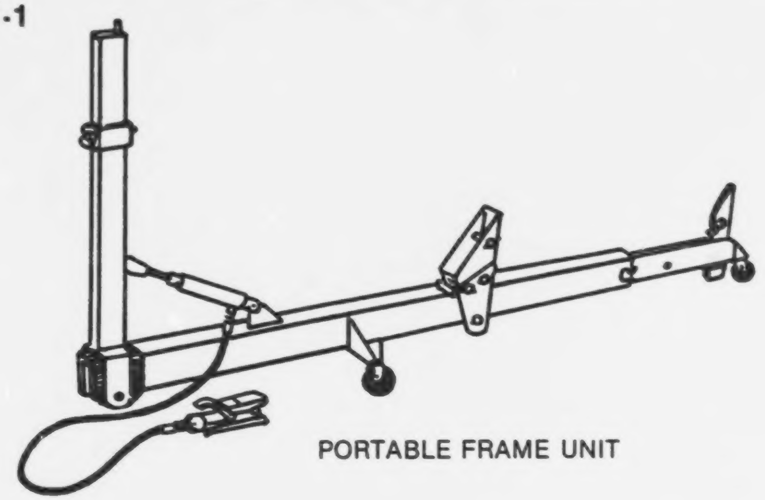
Q. Stationary unit -- Any vehicle frame-straightening unit that cannot be easily transported from car to car.

II. Pulling and anchoring equipment

A. Modern pulling and anchoring systems

1. Portable frame unit (FIG. 1-1)

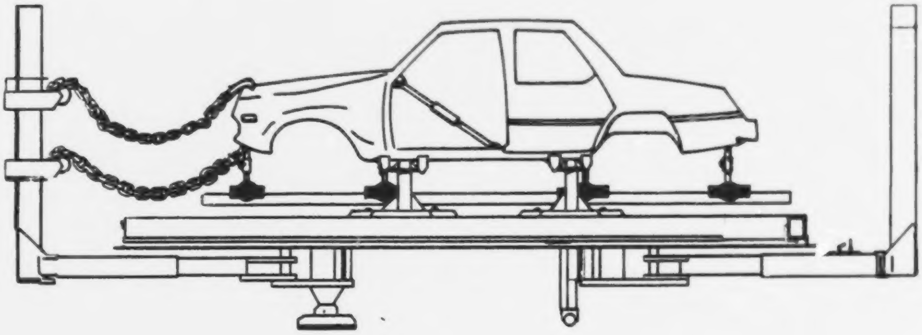
FIGURE 1-1



PORTABLE FRAME UNIT

2. Stationary rack (FIG. 1-2)

FIGURE 1-2

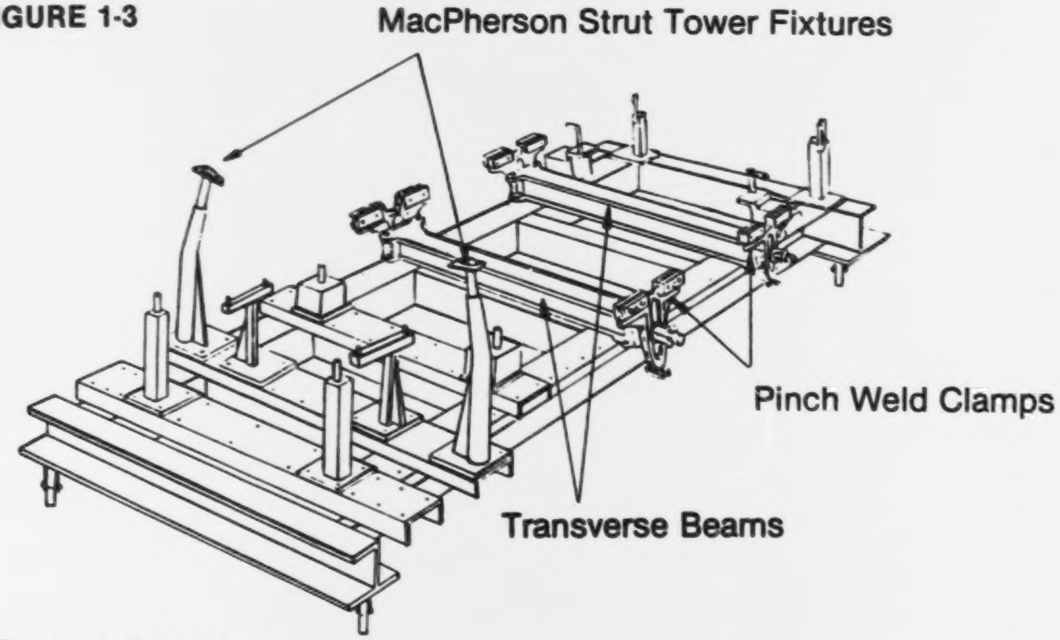


Courtesy of Chart Industries, Ltd.

1242

3. Dedicated or universal bench (FIG. 1-3)

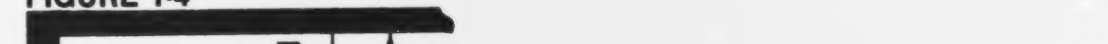
FIGURE 1-3


MacPherson Strut Tower Fixtures
Pinch Weld Clamps
Transverse Beams

Courtesy of Tec-Cor. Inc.

4. Floor anchor, pots or slotted rails (FIG. 1-4), (FIG. 1-5)

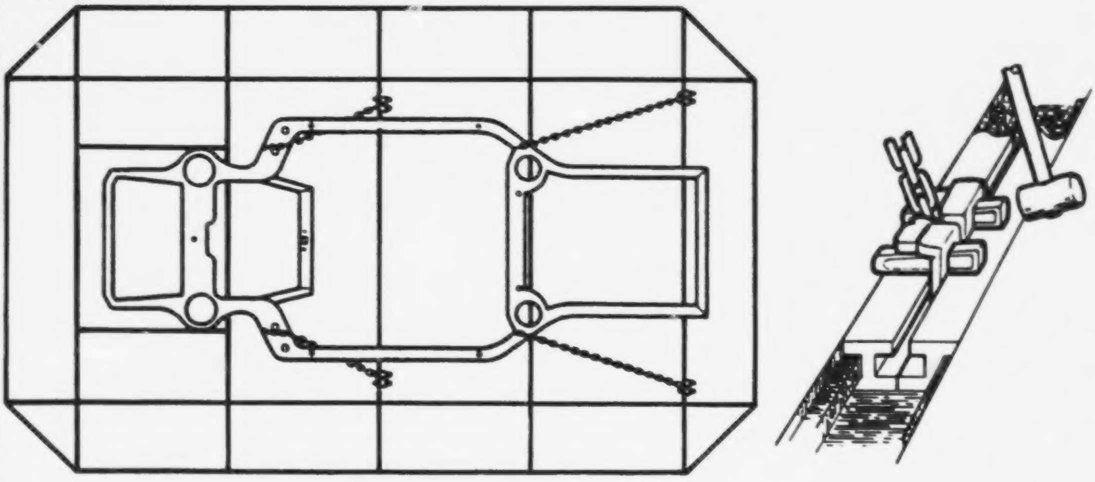
FIGURE 1-4



3 FT
16 POTS
11 POTS
1 FT

Courtesy of Chart Industries, Ltd.

FIGURE 1-5



THE ANCHORING GRID

CHAIN ANCHOR

Courtesy of Blackhawk Automotive, Inc.

B. The components of modern pulling systems

1. An anchoring system
2. Clamps, hooks, attachments and chains
3. Hydraulic jacking equipment

C. Anchoring methods for frame-body vehicles

1. Stationary frame rack with anchoring attachments for frame-body vehicles
2. Stationary floor anchors (pots or slotted rails) with attachments for frame-body vehicles
3. Damage dozer

D. Anchoring methods for unibody vehicles

1. Stationary frame rack with anchoring attachments for unibody vehicles
2. Stationary floor anchors (pots or slotted rails) with attachments for unibody vehicles, including one of the following:
    a. pinchweld clamps
    b. a frame clamp
    c. a dedicated or universal bench

E. Anchoring principles

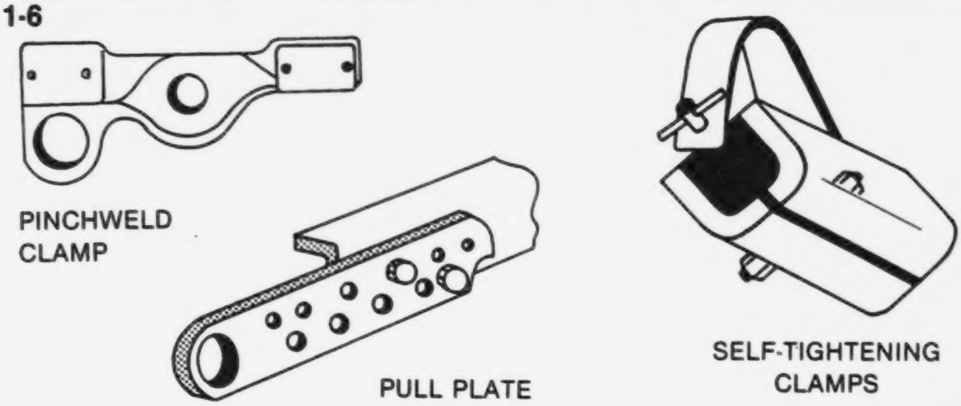
1. The objective of anchoring is to distribute the load of holding the vehicle during the pulling operation.

2. The strongest areas for anchoring are the pinch-welds in the torque box areas, or the frame in the torque box areas. (If vehicle is unibody construction without pinchwelds, consult manufacturer's recommendations.)

F. Principal clamps and hooks in anchoring and pulling operations

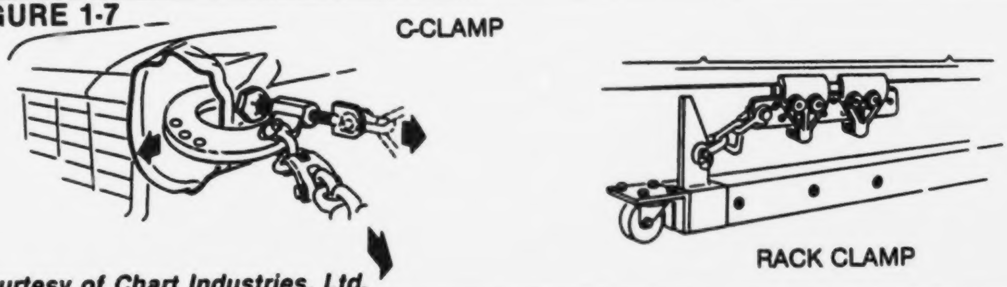
1. The principal clamps used for anchoring are the pinchweld clamp, the self-tightening clamp and the pull plate (FIG. 1-6)

FIGURE 1-6



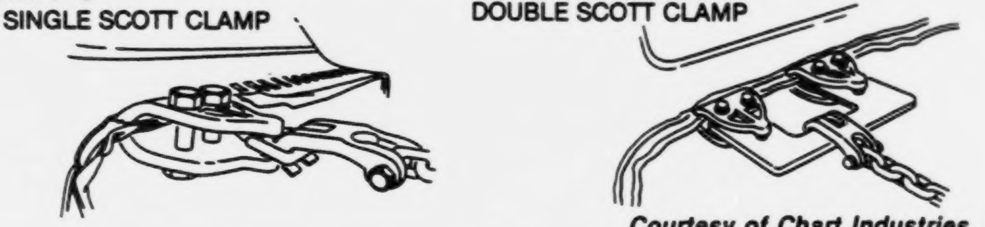
2. Additional clamps include: C-clamp, rack clamp, single-scott clamp, double-scott clamp, double-scott clamp with bar, drawbar (FIG. 1-7, 1-8, 1-9)

FIGURE 1-7



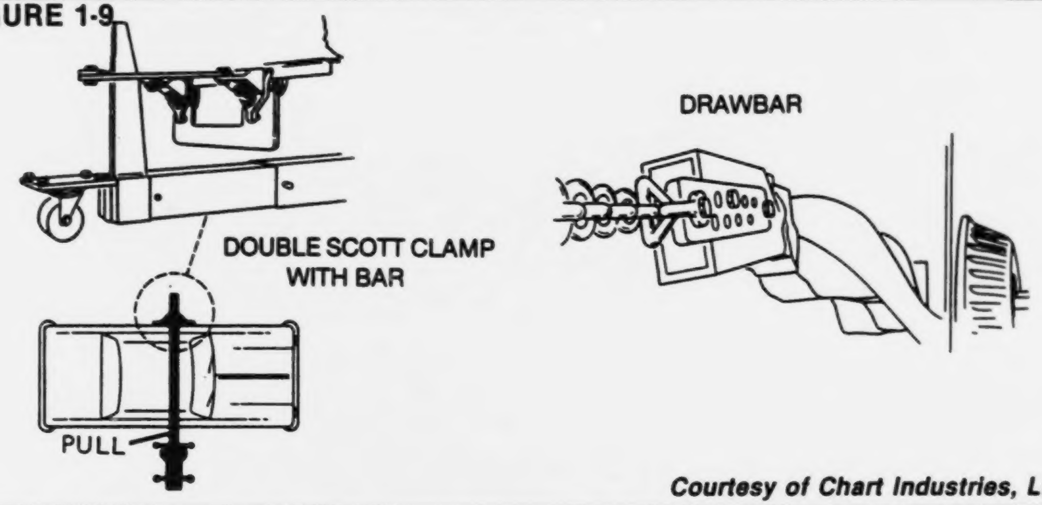
Courtesy of Chart Industries, Ltd.

FIGURE 1-8


SINGLE SCOTT CLAMP
DOUBLE SCOTT CLAMP

Courtesy of Chart Industries, Ltd.

FIGURE 1-9

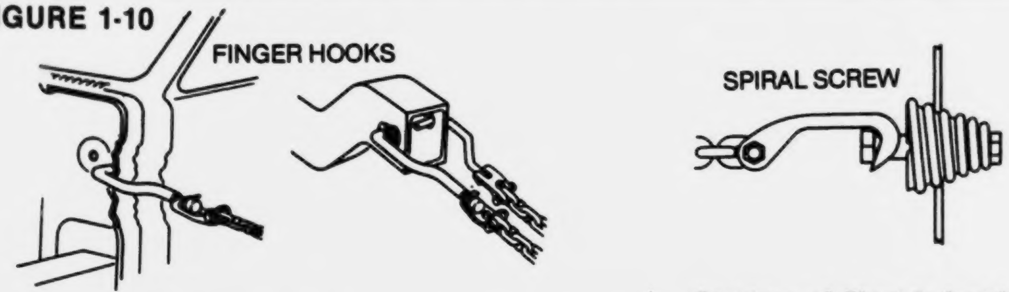

DRAWBAR
DOUBLE SCOTT CLAMP
WITH BAR
PULL

Courtesy of Chart Industries, Ltd.

3. Hooks include: Finger hooks, spiral screw, wedge tip, hook extension, utility tip and extension wedge, plug hook (FIG. 1-10, 1-11, 1-12)

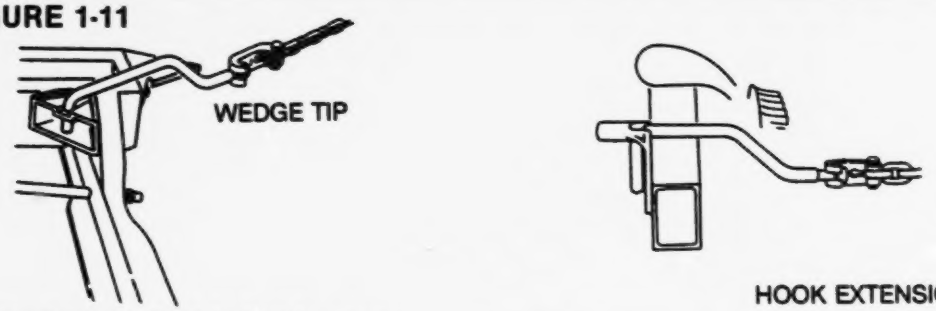
   (Note: There is no "correct" name for many clamps and hooks. The names of clamps and hooks vary from manufacturer to manufacturer.)

FIGURE 1-10


FINGER HOOKS
SPIRAL SCREW

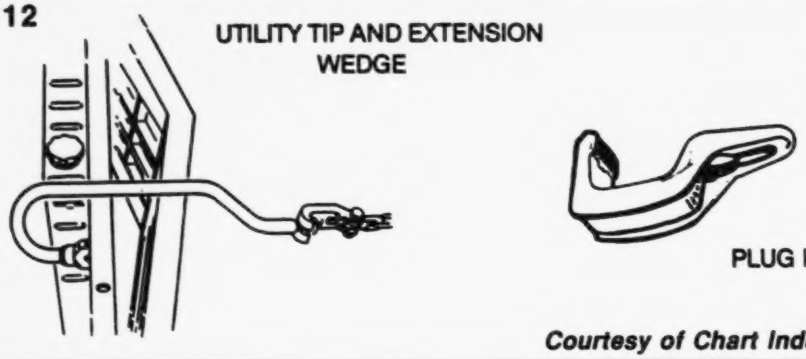
Courtesy of Chart Industries, Ltd.

FIGURE 1-11


WEDGE TIP
HOOK EXTENSION

Courtesy of Chart Industries, Ltd.

FIGURE 1 · 12


UTILITY TIP AND EXTENSION
WEDGE
PLUG HOOK

Courtesy of Chart Industries, Ltd.

G. Principles of using chains

1. Use only approved high-tensile pulling chains.
2. Wrap and cover chains to avoid potential injury if a chain snaps.
3. Use a safety chain when necessary.
4. Do not bolt chains together.
5. Do not pull chains over sharp edges.
6. Do not heat chains.

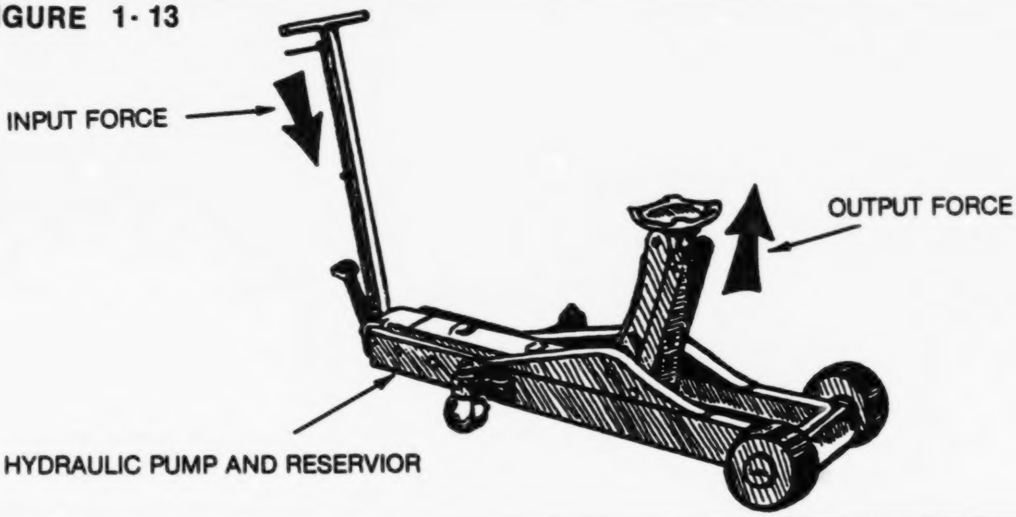
H. Principles of using hydraulic equipment

1. Hydraulic equipment consists of three parts:
    a. A hydraulic fluid reservoir
    b. A hydraulic pump
    c. A hydraulic ram or jack

2. There are two basic types of hydraulic equipment:

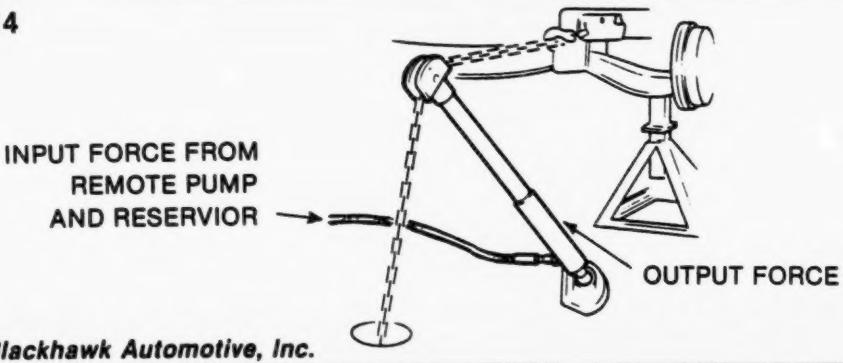
   a. Equipment with the fluid reservoir, pump and ram or jack self-contained. (Usually referred to as jacks). (FIG. 1-13)

FIGURE 1- 13


INPUT FORCE
OUTPUT FORCE
HYDRAULIC PUMP AND RESERVIOR

   b. Equipment with the reservoir and pump separate from the ram or jack and a hydraulic hose connecting the two units. (Usually referred to as rams). (FIG. 1-14)

FIGURE 1-14


INPUT FORCE FROM
REMOTE PUMP
AND RESERVIOR
OUTPUT FORCE

Courtesy of Blackhawk Automotive, Inc.

3. There are two basic ways of providing force for operating hydraulic pumps:

   a. Mechanical force, in which a lever is pumped up and down by the operator.

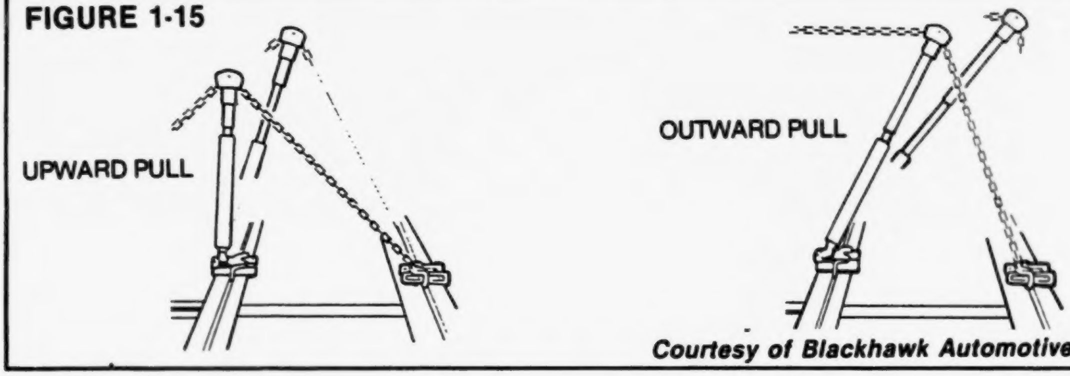
   b. Air-over-hydraulic, in which compressed air takes the place of mechanical force. (Usually air-over-hydraulic units use foot-operated controls).

4. All hydraulic equipment should be checked regularly for proper oil level and for leaks.

5. Hydraulic rams used with floor-anchoring systems require special set-up and operating procedures. (Your instructor will demonstrate the exact procedures if your shop has such equipment). The important things to remember are:

   a. The change in angles caused by the expansion of the hydraulic ram: (FIG. 1-15)

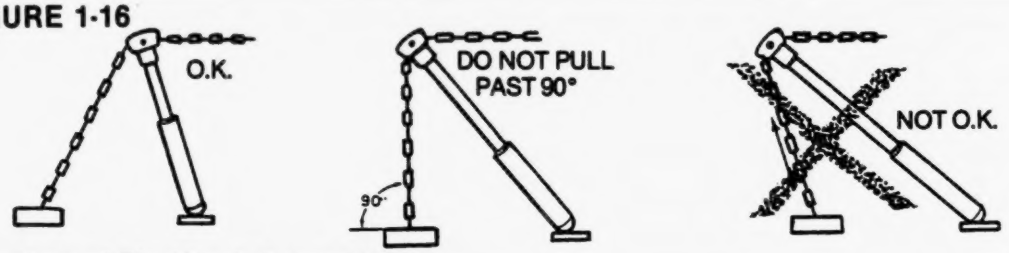
FIGURE 1-15



Courtesy of Blackhawk Automotive, Inc.

   b. That you cannot pull past a 90-degree angle (FIG. 1-16)

FIGURE 1-16



Courtesy of Blackhawk Automotive, Inc.

III. Comparison of the basic modern frame-straightening units

(Note: There is a great variety of frame-straightening units available, including many that combine two or more of the four basic types listed below. Many stationary units, in particular, have been modified for use with a particular measuring system).

A. Portable frame unit (damage dozer)

   1. Provides single-direction pull or push.
   2. Is mounted on wheels and can moved easily; safety stands or other system must support vehicle.
   3. Does not supply ability to anchor an undamaged or corrected control dimension.
   4. Uses a hydraulic ram for pulling power.

5. Will continue to be effective on primary damage to conventional frame vehicles with limited application to unibody damage.

B. Stationary frame rack

1. Provides multiple pulls or pushes.

2. Is usually bolted onto or built into floor of shop; vehicle can be pulled or driven onto rack.

3. Provides multiple pulling and anchoring points.

4. Uses hydraulic rams and/or hydraulic jacks.

5. Is effective on all types of damage, but some units may have limitations in straightening serious unibody damage.

C. Floor anchors used with either (1) frame stands and pinchweld clamps or (2) the frame clamp:

1. Provide multiple pulls or pushes.

2. Are installed into floor, with either pot hole anchors or an anchoring grid; car must be lifted onto stands or clamp.

3. Provide multiple anchoring and pulling points.

4. Used together with air over hydraulic rams, and occasionally hydraulic jacks.

5. Are effective on all types of damage.

D. Universal or dedicated benches:

(Note: Benches started out as measuring systems and not pulling systems. But some benches are now self-contained measuring and pulling systems).

1. Provide multiple pulls or pushes.

2. Can be moved around shop.

3. Provide multiple anchoring and measuring points using different fixtures for different vehicles.

4. Use hydraulic ram pulling arms in self contained units. Other units must use floor anchors.

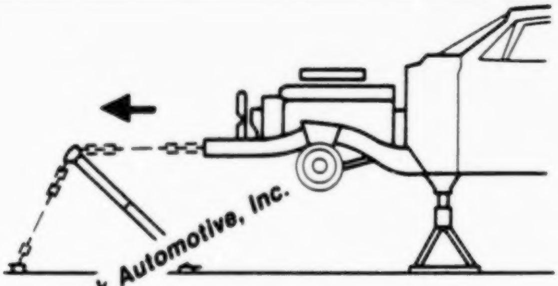
5. Are effective on all types of damage but designed specifically for unibody repair.

IV. Basic pulls and pushes

(NOTE: The pressure applications illustrated are intended to show general structural alignment methods. Exact hookup points and pressure applications are unique to each situation, varying with damage, the vehicle and the type of equipment).

A. The straight-out pull (FIG. 1-17)

FIGURE 1-17



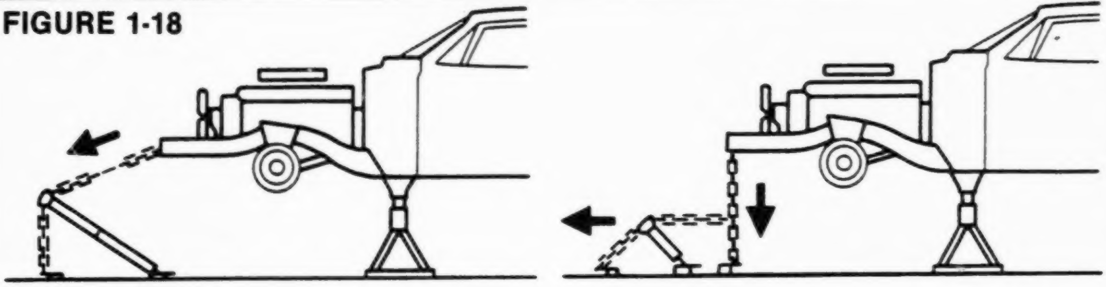
STRA STRAIGHT OUT PULL

Courtesy of Blackhawk Automotive, Inc.

B. Down-and-out pull (FIG. 1-18)

C. Down pull using chain bridge (FIG. 1-18)

FIGURE 1-18



DOWN AND OUT PULL

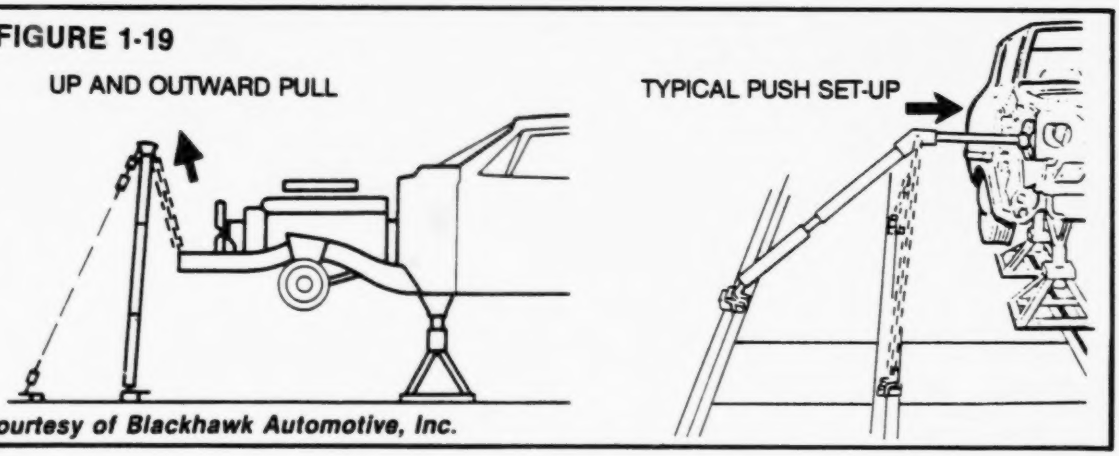
DOWN PULL USING A CHAIN "BRIDGE"

Courtesy of Blackhawk Automotive, Inc.

D. Up-and-outward pull (FIG. 1-19)

E. Inward push (FIG. 1-19)

FIGURE 1-19


UP AND OUTWARD PULL
TYPICAL PUSH SET-UP

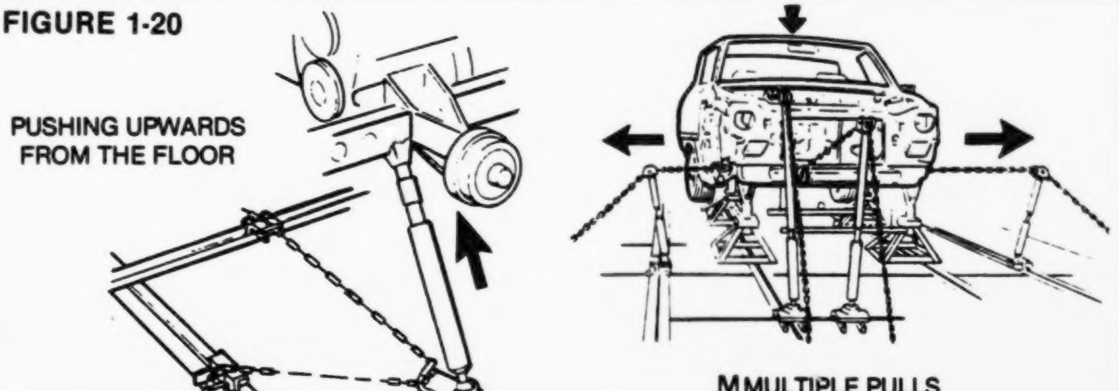
Courtesy of Blackhawk Automotive, Inc.

F. Upward push (FIG. 1-20)

G. Multiple pulls: (FIG. 1-20)

1. Multiple pulls eliminate the chance of metal tearing by spreading the force of the pulls.
2. Multiple pulls are often necessary for unibody repair.

FIGURE 1-20


PUSHING UPWARDS
FROM THE FLOOR
MMULTIPLE PULLS

Courtesy of Blackhawk Automotive, Inc.

V. **Basic frame repair guidelines for both conventional and unibody construction**

A. Frame damage is repaired in the opposite sequence in which it occurred.

B. In general, the sequence of damage is: sidesway, sag, mash, twist and diamond.

C. In general, the order of repair is reverse of sequence of damage: diamond, twist, mash, sag, sidesway.

D. Although diamond damage occasionally occurs in unibody vehicles, it is usually not economical to repair.

E. Pulls should be made in the opposite direction of the direction of impact.

F. In planning repairs remember the "Last-in, first-out" rule. This means that you must plan repairs such that the last damage that occurred in the collision is the first damage to be completely repaired.

(Note: "Last-in, first-out" does not mean you start pulling directly on secondary damage. It means that regardless of what pulls must be made, the first damage to be COMPLETELY repaired will be the last damage the vehicle received).

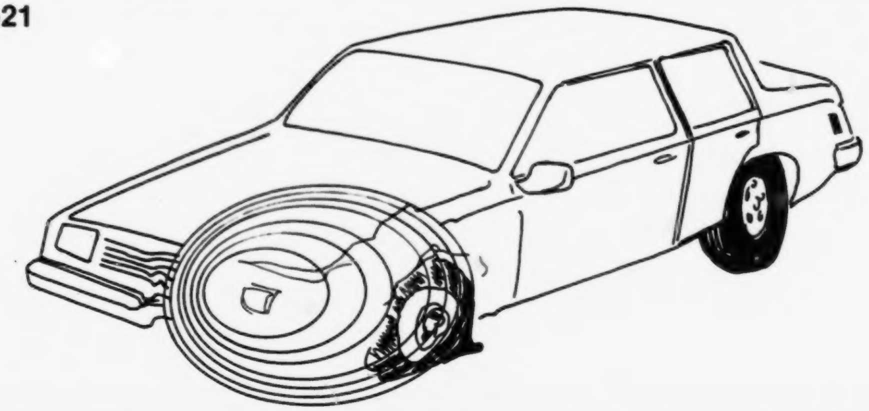
G. Put a slight load on the pulling equipment to see how the damaged area reacts and to check the anchoring of the vehicle. Walk around the vehicle and check clamps and control points.

H. In analyzing damage and planning repairs, think of how you would pull the damage if you could do it with your bare hands.

I. Avoid overpulling on both conventional and unibody construction. Overpulling generally results from failing to measure accurately or failing to measure often. Damaged metal pulled or stretched beyond the critical control dimension can be difficult to shrink or compress and in most cases must be replaced. Apply finesse instead of force.

VI. The cone concept (FIG. 1-21)

FIGURE 1-21



A. The cone concept is a means of visualizing the damage caused in a collision to a unibody vehicle. Damage in unibody vehicles can be described using a cone concept, just like an ice cream cone.

B. The unibody folds and collapses as it absorbs the impact of a collision. As the force penetrates the structure, it is absorbed in an ever-increasing area of the unibody until completely dissipated.

C. The point of impact is the tip of the cone. The center line of the cone points in the direction of the impact.

D. The tip of the cone is the area of primary damage.

E. As the force travels and the cone spreads, secondary damage occurs, generally toward the vehicle's opposite end or side.

VII. Partial replacement of frame sections

A. In conventional frames it is occasionally possible to cut and replace a section of a damaged frame rail or frame horn, rather than replacing the entire frame rail or frame horn.

B. Generally, it is necessary to fishplate sectioned frame rails or frame horns.

C. In fishplating, make only horizontal welds along the top and bottom edge of the reinforcing plate. Do not make vertical welds on the ends. The welds attaching the sections (not the fishplate) should be continuous.

D. Alignment of the frame must be complete to specifications prior to sectioning, or as close to specifications as damage allows.

(Note: It will be necessary to perform stress relief).

E. Use a MIG welder.

F. An oxyacetylene torch can be used to cut conventional frames.

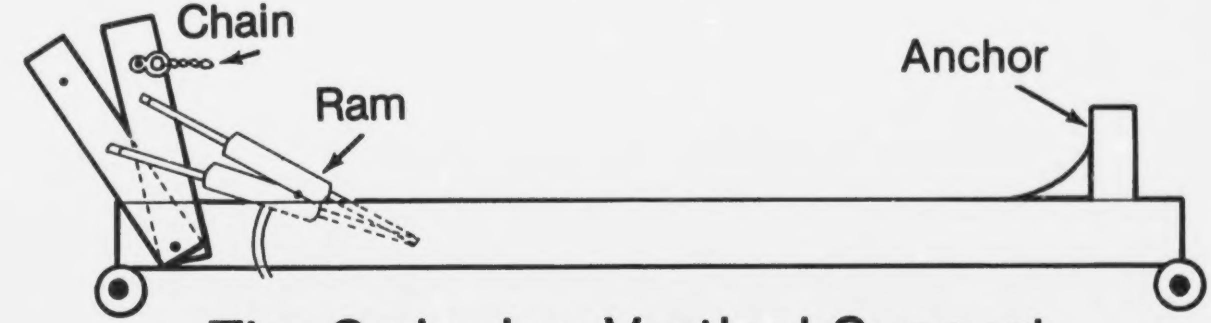
G. General sequence of replacing partial frame section

1. Prepare frame rail or horn for sectioning by removing obstructing panels.

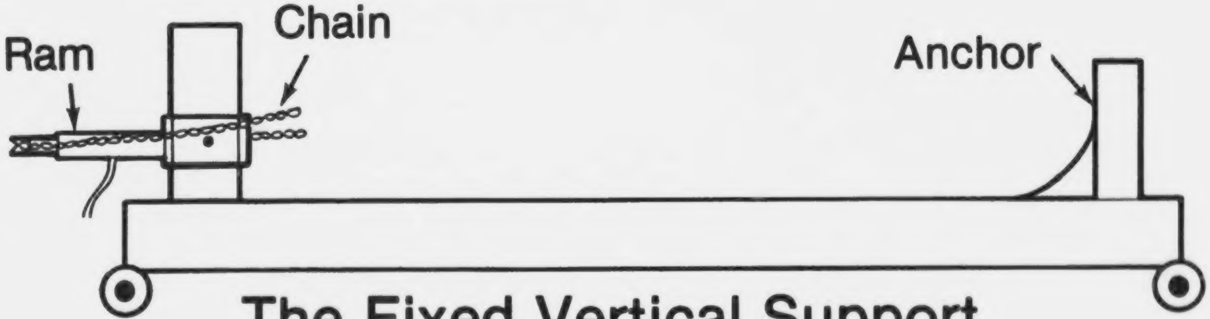
   (CAUTION: *Remove gas lines if near area to be sectioned).*

2. Weld any cracks or tears in frame and pull to correct alignment.
3. Remove damaged section.
4. Cut replacement section.
5. Grind and clean joints to be welded.
6. Clamp replacement section into proper alignment.
7. Weld using appropriate welds and techniques.
8. Cut reinforcing plate of appropriate size from appropriate material, if needed.
9. Weld reinforcing plate using only horizontal welds.
10. Apply paint or undercoating.
11. Re-install removed components and complete repairs.

Portable Frame Straightening Units


Chain
Ram
Anchor

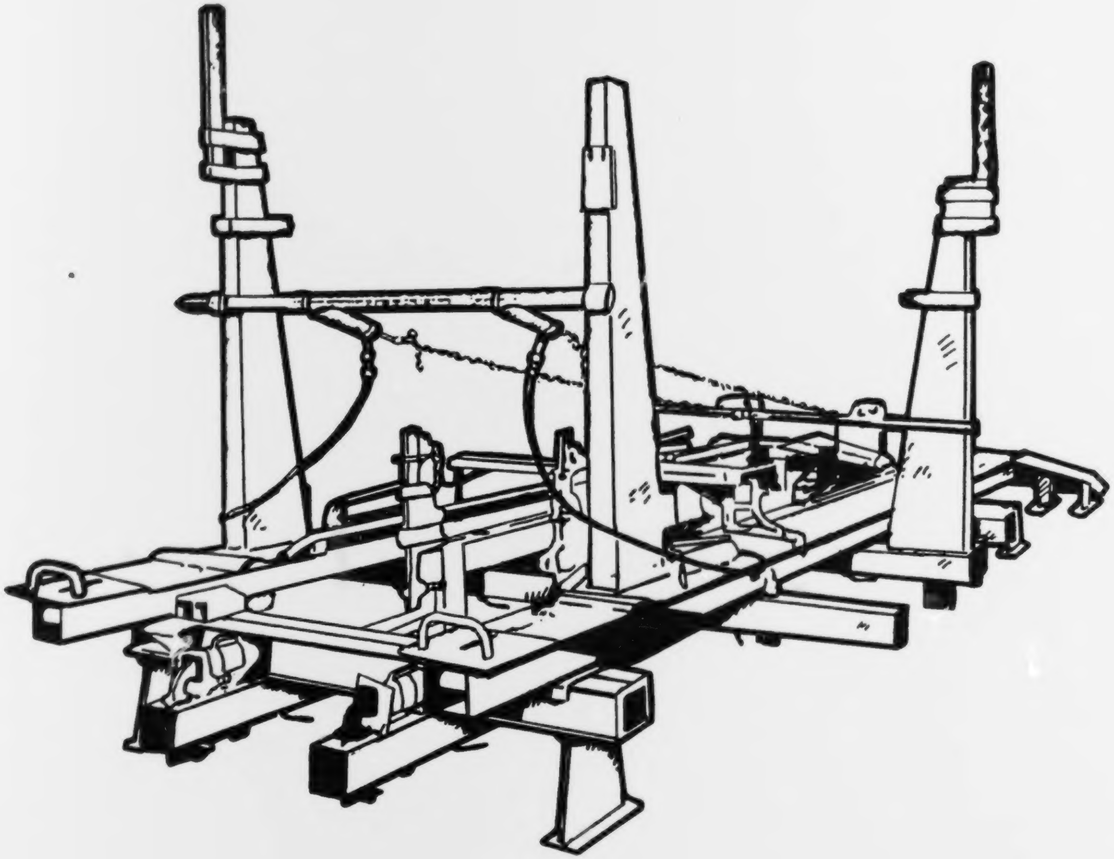
The Swinging Vertical Support


Ram
Chain
Anchor

The Fixed Vertical Support

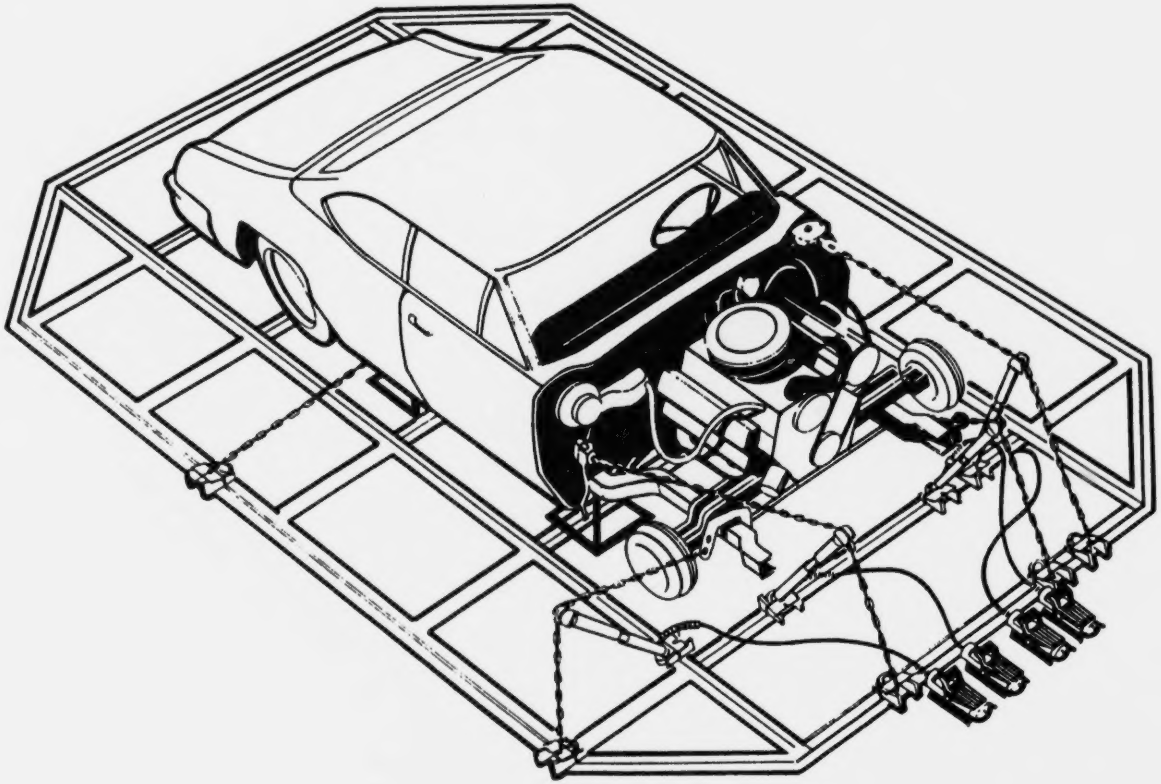
TM 1

Stationary Frame Unit



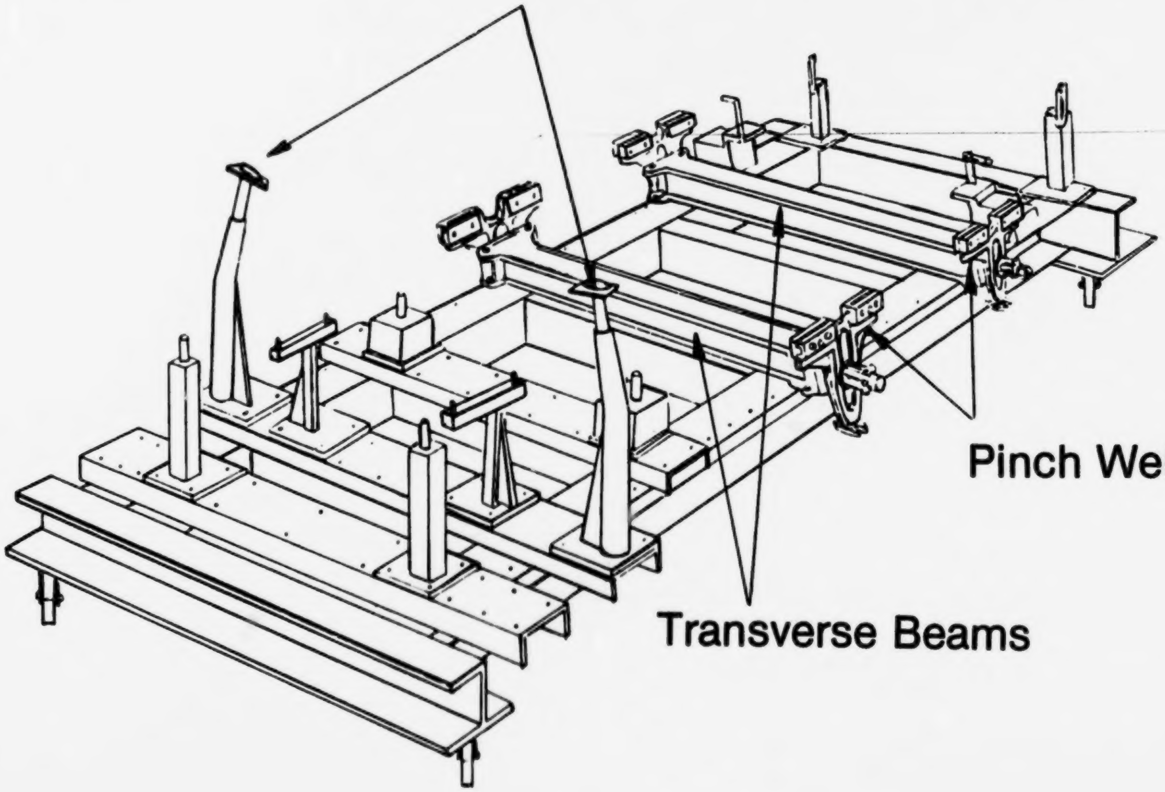
TM 2

Stationary Floor Mount Unit



TM 3

Dedicated Bench



MacPherson Strut Tower Fixtures

Pinch Weld Clamps

Transverse Beams

Courtesy of Tec-Cor. Inc.

TM 4

I-FRAME - 271

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT VII: FRAME REPAIR TECHNIQUES AND EQUIPMENT

UNIT VII TEST

I. Match the terms in the left column with the most closely associated definition or illustration in the right column.

_____1. Portable unit

_____2. Combination Damage

_____3. Cone concept

_____4. Secondary damage

_____5. Fishplating

_____6. Floor anchor

_____7. Stationary rack

_____8. Anchoring objective

_____9. Torque box areas

A. More than one type of frame damage

B. Provides only one pull at a time

C. Distributing load of holding vehicle

D. Reinforcement welded to conventional frame

E. Strongest place for anchoring vehicle

AB. Way of visualizing damage

AC. Uses pots or slotted rails

AD. Vehicle is driven onto rack

AE. Damage occurring as a result of primary damage

II. Match the illustration of the pull in the right column with the name of the pull.

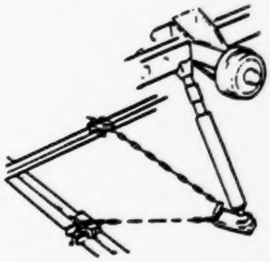
_____10. Outward and upward pull

_____11. Down pull

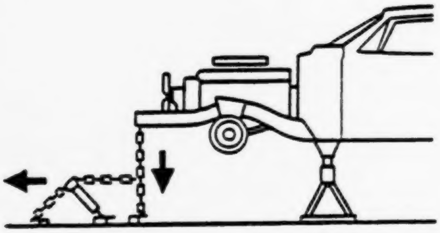
_____12. Upward push

_____13. Straight out pull

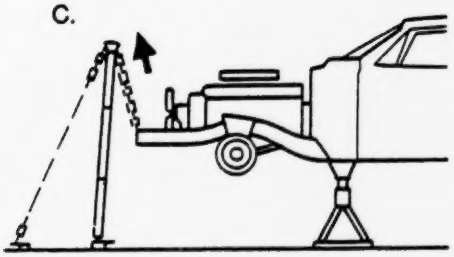
A.



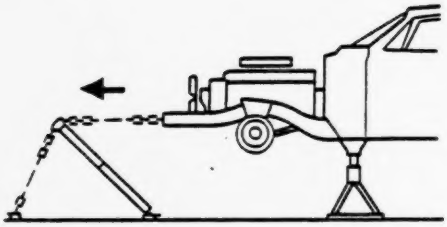
B.



C.



D.



III. Order the sequence in which the five types of frame damage generally occur by ordering the letters. The letter of the first type of damage would be answer 14, the next one would be 15, etc.

_____14.

_____15.

_____16.

_____17.

_____18.

A. Sag

B. Twist

C. Sidesway

D. Diamond

E. Mash

(NOTE: Completion of this unit with a minimum score of _____ is necessary for the student to receive an evaluation on Competency Y1.)

ANSWERS TO UNIT VII TEST

1. B
2. A
3. AB
4. AE
5. D
6. AC
7. AD
8. C
9. E

10. C
11. B
12. A
13. D

14. C
15. A
16. E
17. B
18. D

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT VIII: DAMAGE REPAIR PROCEDURES

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to describe and use frame repair procedures, straighten conventional and unibody frame damage, and perform stress relief. Mastery will be evidenced through demonstration and by scoring _____% on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Identify terms and definitions (Competencies Y3 and Y4, Unit VIII test)

II. Identify principles of stress relief (Competencies Y3 and Y4, Unit VIII test)

III. Demonstrate the ability to:

  a. Perform stress relief using heat (Competency Y4, Job Sheet #1)

  b. Perform stress relief using shock (Competency Y3, Job Sheet #2)

Lesson 2:

I. Identify principles of frame-straightening procedures (Competency Y1, Unit VIII test)

II. Identify the sequence of straightening damage (Competency Y1, Unit VIII test)

III. Name safety procedures for pulling operations (Competency Y1, Unit VIII test)

IV. Demonstrate the ability to:

  a. Plan repair sequences (Competency Y1, Assignment Sheet #1)

  b. Prepare a vehicle for frame repair (Competency Y1, Job Sheet #1)

  c. Straighten and align diamond damage (Competency Y1, Job Sheet #2)

  d. Straighten and align twist damage (Competency Y1, Job Sheet #3)

  e. Straighten and align mash damage (Competency Y1, Job Sheet #4)

  f. Straighten and align sag damage (Competency Y1, Job Sheet #5)

  g. Straighten and align sidesway damage (Competency Y1, Job Sheet #6)

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT VIII: DAMAGE REPAIR PROCEDURES

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plans

1. Lesson 1: Relieving stress in structural steel

   a. Information outline

   b. Handout

      HO #1: Shape and state of steel

   c. Job sheets

      JS#1: Perform shock relief
      JS#2: Perform heat relief

2. Lesson 2: Straightening the five types of damage

   a. Information outline

   b. Handouts

      HO#1: Straightening diamond and twist damage
      HO#2: Straightening mash damage
      HO#3: Straightening sag damage
      HO#4: Straightening sidesway damage

   c. Assignment sheet

      AS #1: Plan repair sequences

   d. Answers to assignment sheet

   e. Job sheets:

      JS#1: Prepare vehicle for frame repair
      JS#2: Straighten diamond damage
      JS#3: Straighten twist damage
      JS#4: Straighten mash damage
      JS#5: Straighten sag damage
      JS#6: Straighten sidesway damage

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Assignment Sheet #1 does not evaluate a competency. It is presented as good practice for the students.

REFERENCES USED IN WRITING THIS UNIT

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2. Chart Industries, Ltd. *Chart's Unibody Repair Program.* Chart Industries, Ltd. Pickering, Ontario. N.D.

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6. Inter-Industry Conference on Auto Collision Repair. Unibody Auto Collision Repair Training Program. *Measuring and Fixturing Systems.* D.I.A. Communications. Des Plains, IL. 1981.

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10. Rhone, L.C., and Yates, H. David. *Total Auto Body Repair.* Second edition, Bobbs-Merrill Educational Publishing. Indianapolis, IN. 1983.

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MODULE: FRAME CONSTRUCTION AND REPAIR

UNIT VIII: DAMAGE REPAIR PROCEDURES

LESSON 1: RELIEVING STRESS IN STRUCTURAL STEEL

I. **Terms and definitions**

A. Compressed -- A state of steel in which more molecules exist in a given area than would exist in a normal state (also called tension).

B. Grain -- The molecular pattern of steel.

C. Heat Crayon -- A material that melts at a specific temperature which can be applied to the surface of metals near the heated area to determine when the desired temperature has been reached during stress relief.

D. Heat Relief -- The application of heat to eliminate distortions in the grain of steel.

E. High-Strength Steel -- Any of a number of special steels used in unibody construction having higher strength and flexibility than mild steel. They are used to achieve weight reduction in vehicles and most high strength steels have lower tolerances for heat than mild steel.

F. Relaxed State -- The normal, undamaged state of the grain of steel.

G. Shock Relief -- The application of hammer blows to eliminate distortions in the grain of steel.

H. Stress -- The state of steel when the grain has been stretched or compressed.

I. Stress relief -- The application of heat or shock to eliminate distortions in the grain of steel.

J. Stretched -- A state of steel in which fewer molecules of steel exist in a given area than would exist in a normal state.

II. **Principles of stress relief**

A. Returning steel to its original shape does not mean it has been returned to its original strength.

B. Using stress relief, many damaged steel components can be returned to both their original shape and strength.

C. Straightening a damaged area without stress relief leaves the original area of stress and may create new and additional areas of stress.

D. Stress can be relieved by using heat or shock or both.

E. It is important to determine that the metal has not been damaged beyond repair. (In general, if the component in question is not kinked, buckled or torn it maybe returned to its original dimensions and strength).

F. When steel is damaged the grain of the metal is stretched on one side of the damaged component and compressed on the other side.

G. Stress relief returns the steel to a normal, relaxed state from both stretched and compressed conditions.

H. Pulling pressure must be applied for stress relief.

I. Pressure always should be applied by pulling on the component in the opposite direction of the damage.

(NOTE: Before attempting stress relief the component should be firmly anchored and pulling equipment properly attached.)

J. In both shock and heat relief, the pressure applied must be less than the pressure required to straighten the damage without stress relief.

K. Principles of shock relief

1. Use a flat-surfaced hammer of appropriate size.
2. Strike the area of damage in the area where the metal has been stretched.
3. As the damaged component moves back toward its original shape, repeat pressure and shock.

(NOTE: It is very important to note that the shock is causing the metal to return to its normal state and not the pressure from the pull. If shock relief does not work, heat relief should be applied.)

L. Principles of heat relief

1. Heat the damaged area of the metal while pressure is applied.
2. Use an oxyacetylene torch with a neutral flame.
3. Check the factory specifications of the metal to receive stress relief. Manufacturer's recommendations vary considerably.
4. Paint or foreign materials should be removed from the damaged areas.
5. Limit working time on metal. Consult manufacturer's recommendations.
6. Stress relief with heat cannot be performed an unlimited number of times. If after the area is heated twice it has not returned to normal shape, state and alignment, the component will probably have to be replaced.
7. Allow metal to cool naturally. Do not use water or compressed air. Accelerating the cooling will affect the shape and strength of the component.
8. To assure correct temperature, use temperature indicating crayons (heat crayons.)
9. When heating mild steel, use heat crayons or do not heat beyond a dark cherry-red.
10. Attempt shock relief before heat relief. If shock relieve does not work, use heat relief. If heat relief does not work, use both heat relief and shock relief.

(When using shock together with heat, special attention to all safety procedures should be observed and safety equipment must be worn properly during all stress-relieving procedures.)

M. Advantages

1. Unitized vehicles and high-strength steels magnify the importance of stress relief.

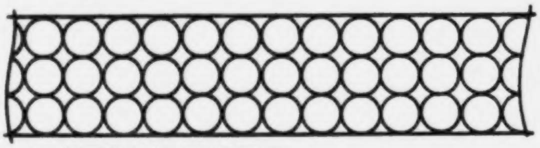
2. Stress relief can eliminate the need to replace and/or section components.

3. Stress relief is effective when properly applied, allowing components to retain original structural integrity.

Two Separate Problems:

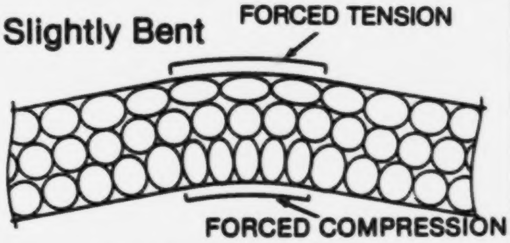
1. Shape
2. State

Unbent



- METAL IS UNBENT
- GRAIN (MOLECULES) IN A RELAXED, COMFORTABLE STATE

Slightly Bent

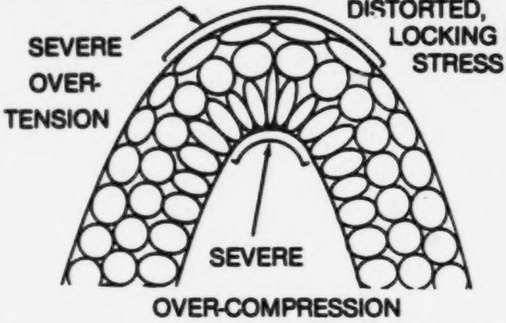

FORCED TENSION
FORCED COMPRESSION

- METAL IS SLIGHTLY BENT
- GRAIN IS FORCED TO EXPAND ON OUTSIDE OF BEND AND COMPRESS ON INSIDE
- IF METAL IS FLEXIBLE, GRAIN WILL RETURN TO COMFORTABLE STATE

Overbent

(BEYOND ELASTIC LIMIT)

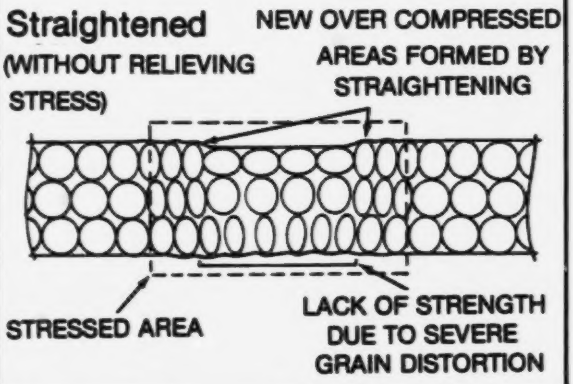
- METAL IS SEVERELY OVERBENT
- GRAIN PATTERN DISTORTED, LOCKING IN STRESS


SEVERE OVER-TENSION
SEVERE OVER-COMPRESSION

Courtesy of Blackhawk Automotive, Inc.

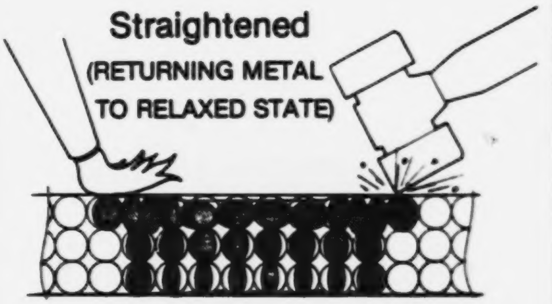
Straightened

(WITHOUT RELIEVING STRESS)


NEW OVER COMPRESSED AREAS FORMED BY STRAIGHTENING
STRESSED AREA
LACK OF STRENGTH DUE TO SEVERE GRAIN DISTORTION

Straightened

(RETURNING METAL TO RELAXED STATE)



GRAIN BEGINS TO RELAX AND RETURN TO ITS ORIGINAL STATE RELIEVING STRESS

Courtesy of Blackhawk Automotive, Inc.

JOB SHEET #1, LESSON ONE

PERFORM STRESS RELIEF USING SHOCK

Equipment

Component part with stress damage
Manufacturer's specifications for component
Measuring equipment
Anchoring and pulling equipment
Flat-surfaced hammer

Safety procedures:

1. Shock relief should always be applied with care and judgment. All safety procedures relating to the use of frame repair equipment and the use of hand tools should be followed.

2. Wear appropriate protective eyewear.

Procedure:	**Evaluation:** 3	2	1	N
1. Locate and identify damage.	___	___	___	___
2. Attach pulling equipment and initiate pull.	___	___	___	___
3. Apply shock by striking damaged area with hammer.	___	___	___	___
Average of above evaluations*	___	___	___	___

(NOTE: Repeat procedure if needed. If stress is not relieved, attempt heat relief.)

*This average is the evaluation for competency Y3, "Perform stress relief using shock."

JOB SHEET #2, LESSON ONE

PERFORM STRESS RELIEF USING HEAT

Equipment

Component part with stress damage
Manufacturer's specifications for component
Measuring equipment
Anchoring and pulling equipment
Oxyacetylene welder with neutral flame
Heat crayons for appropriate temperature

Safety procedures:

1. Stress relief should always be applied with care and judgement. All safety procedures relating to the use of frame repair equipment, the use of gas welders and the use of hand tools should be followed.

2. Never touch a heated area, even with a gloved hand.

3. Wear appropriate protective eyewear.

Procedure:	**Evaluation:** 3	2	1	N
1. Locate and identify damage.	___	___	___	___
2. Attach pulling equipment and initiate pull.	___	___	___	___
3. Mark damaged area with heat crayon that meets manufacturer's recommendations, applying approximately one inch around outer edge of affected area.	___	___	___	___
4. Using gas welder, apply heat to damaged area until crayon melts and repeat procedure until stress is relieved.	___	___	___	___
Average of above evaluations*	___	___	___	___

*This average is the evaluation for competency Y4, "Perform stress relief using heat."

(NOTE: If stress is not relieved, attempt heat relief in conjunction with shock relief. Allow gradual cooling.)

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT VIII: DAMAGE REPAIR PROCEDURES

LESSON 2: STRAIGHTENING AND ALIGNING THE FIVE TYPES OF DAMAGE

I. **Principles of straightening the five kinds of damage for unibody and frame-body vehicles**

  A. The basic guidelines for analyzing and straightening the five kinds of frame damage are the same for frame-body and unibody frame construction, except that repairable diamond damage usually does not occur in unibody vehicles.

  B. The anchoring points and specific pulls may vary from vehicle to vehicle, whether unibody or frame-body. Vehicle specifications and extent of damage will determine specific hookup points and pull procedures.

  C. Weld any tears in components prior to starting pull. Reinforce weakened or badly corroded areas.

  D. The objective of all pulls is to restore damaged metal back to its original shape, state and alignment.

  E. Additional guidelines apply to unibody frame repair

    1. When pulling, remove damaged metal only when absolutely necessary. Damaged metal can be used as an attachment point for a later pull.

    2. If you have to cut a seam, make sure you are ahead of the factory seams.

    3. All parts should be straightened to mate as closely as possible to fixtures or to matching flanges even though they will be cut off and replaced. This assures that replacement parts fit properly.

    4. The vehicle must be anchored by at least three undamaged control points.

    5. Strive for hookups that will distribute the pressure of the pull over a wide area of the vehicle.

  F. There are six basic steps in the principal sequence of straightening damage

    1. Analyze damage and plan repair

    2. Anchor vehicle

    3. Initiate pull(s)

    4. Measure progress

    5. Perform stress relief, if needed

    6. Repeat steps 3 and 4 until pull is complete.

II. **Guidelines for the sequence of straightening damage**

  A. Analyze damage and plan repair

1. Support the vehicle so it can be measured and evaluated.

2. Draw a diagram of the collision.

3. Double-check your evaluation of the direction and depth of impact force.

4. Plan a repair sequence – a logical sequence of pulling and straightening procedures that will result in the overall effect of reversing or unfolding the collision damage.

   a. Determine pulls required.

   b. Determine hookup points per vehicle specifications.

   c. Determine order of pulls.

   (Note: Remember the reverse sequence rule, "last-in, first-out." Straighten secondary damage to specifications first and remove all damage in the opposite sequence in which it occurred.)

B. Anchor vehicle and attach pulling equipment

1. Double-check vehicle and equipment manufacturer's specifications for anchoring and hookup points as determined in planning repair sequence, then anchor the vehicle.

   (Note: If there is any doubt about adding another anchor, then add it. You cannot over-anchor a vehicle as long as the anchor doesn't interfere with the pull.)

2. Set up pulling equipment and operate it with full consideration of good safety practices and consult instructor after making set-up.

3. Leave as much gauging equipment in place as possible, as long as the pull is not likely to damage the equipment.

4. Remove only those component parts essential to make hookups or essential to ensuring safety.

5. Distribute pressure of pull over largest possible area of damage (especially for unibody vehicles.) More hookups will distribute the stress of the pull to a larger area and damage as a result of the pull is less likely.

C. Initiate pull

1. Put a slight load on the pulling equipment and see how the damaged area reacts and check the way you have anchored the vehicle. Walk around the vehicle and check clamps and control points.

2. Make low-pressure pulls and measure often.

D. Perform stress relief

1. Follow manufacturer's recommendations and use heat crayons.

2. If in doubt, do not heat it. Treat all metal as though it were high-strength steel.

E. Measure progress after each application of pressure unless you are absolutely certain another application of pressure will not result in overpulling. Relieve pressure from pulls prior to measuring.

F. Repeat sequence of (a) applying pressure, and (b) measuring as often as necessary until frame component reaches normal shape, state and alignment. Apply stress relief as needed.

(NOTE: Lock straightened components into place with proper anchoring before starting new pulls.)

III. Safety

A. Follow equipment manufacturer's specifications for attaching and operating pulling or anchoring equipment.

B. Double-check hookups to make certain they are secure. Do not wrap chains around sharp edges.

C. Mask or cover all broken glass and label "Danger." Tape any glass that could break during pull.

D. Use just enough pressure to do job and stop pulls frequently to check equipment and progress of pull.

E. Use only appropriate equipment and make sure all equipment is in good working order before starting pull.

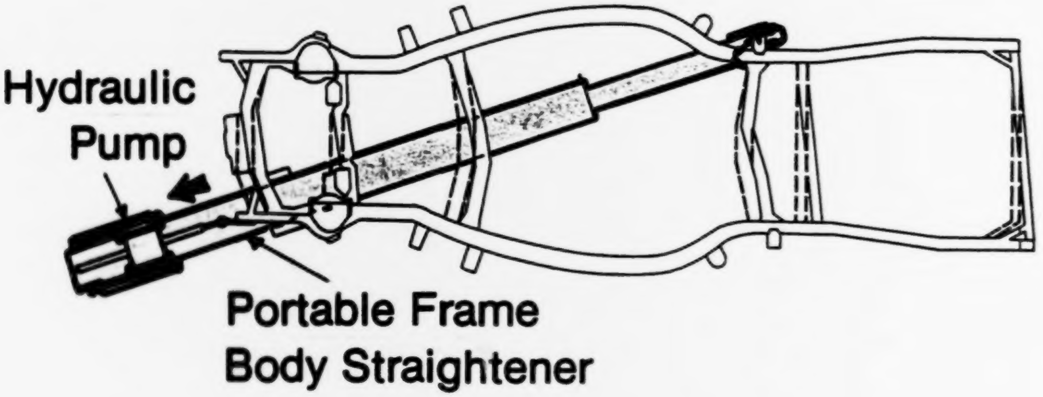
F. Do not damage hydraulic hoses. Avoid heat, sharp objects or any outside pressure.

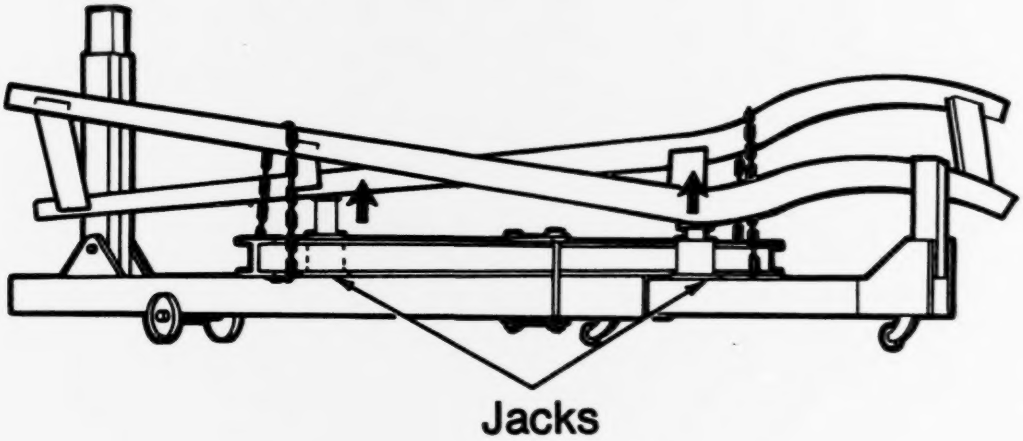
G. Keep yourself and others away from the line of the pull and keep your hands and body well away from equipment and attachments during pulling operations. Inform everyone in the shop prior to making a pull.

H. Double-check all hookups before starting pull and attach a secondary safety chain or cover chain.

I. When using pinchweld clamps, make sure the undercoating or any other foreign substance is removed so the clamp gets a firm grip. Make sure clamp teeth are clean and sharp for a firm grip.

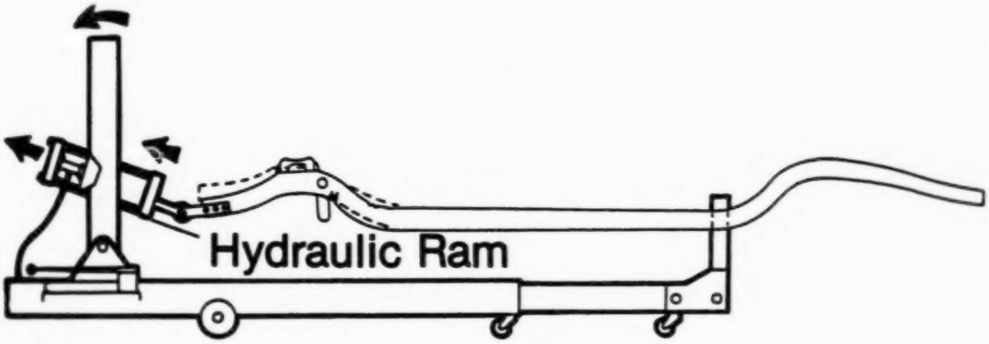
Straightening Diamond & Twist in Frame Body

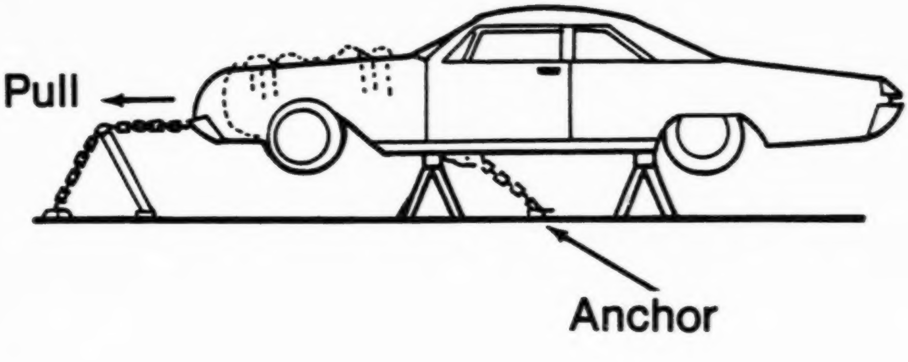

Hydraulic Pump
Portable Frame Body Straightener



Courtesy of Blackhawk Automotive, Inc.

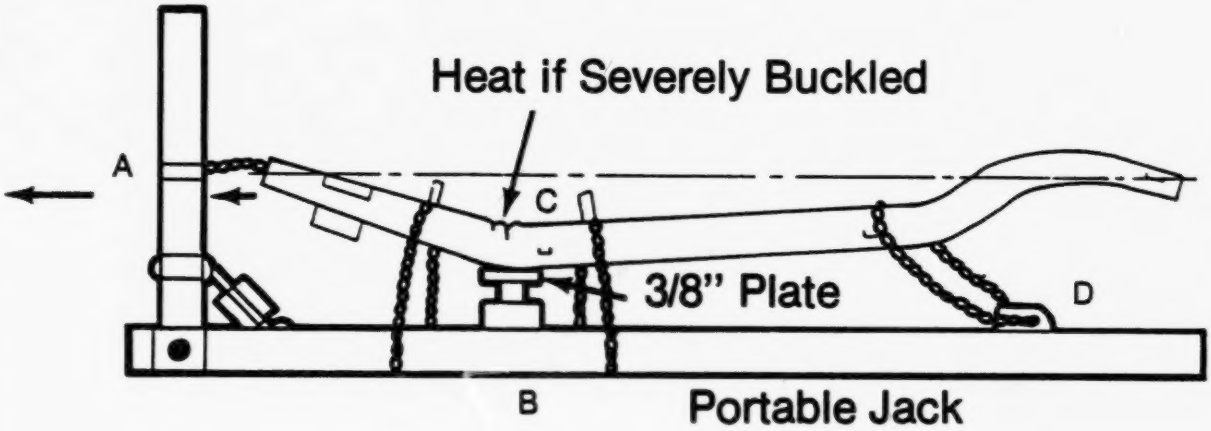
Straightening Mash in Frame Body & Unibody

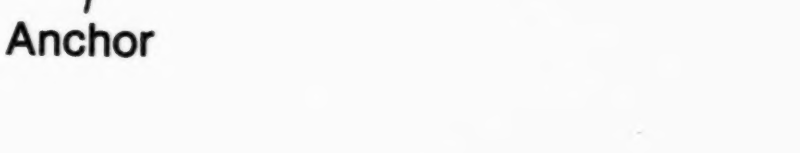

Hydraulic Ram


Pull
Anchor

Courtesy of Blackhawk Automotive, Inc.

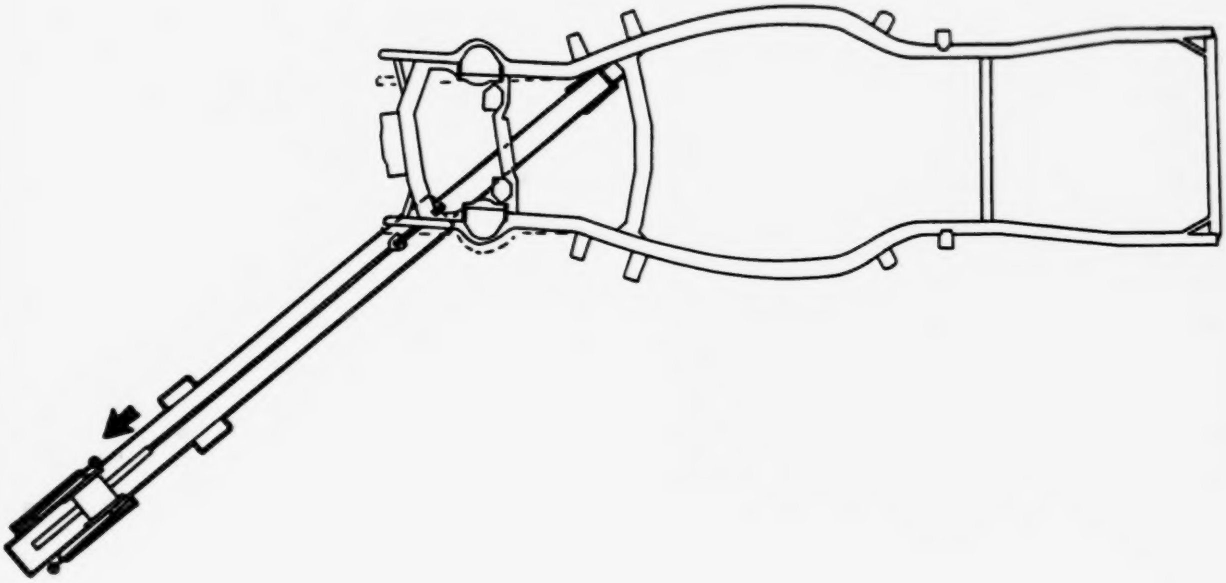
Straightening Sag in Frame Body & Unibody

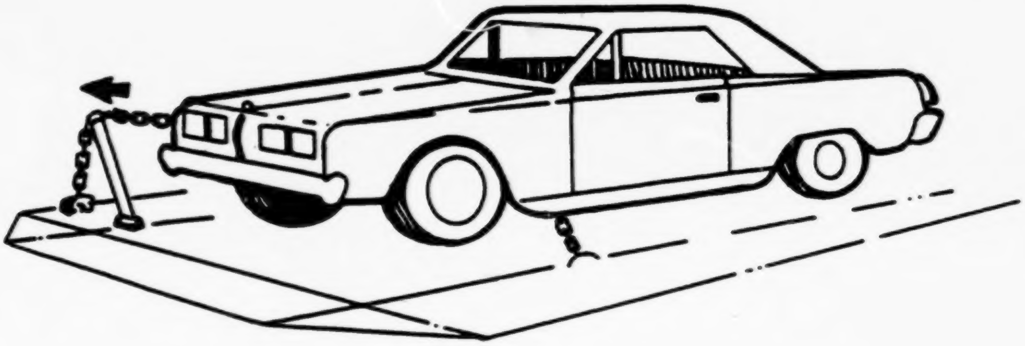

Heat if Severely Buckled
A
C
3/8" Plate
D
B
Portable Jack


Anchor
Anchor

Courtesy of Blackhawk Automotive, Inc.

Straightening Sidesway in Frame Body & Unibody





Courtesy of Blackhawk Automotive, Inc.

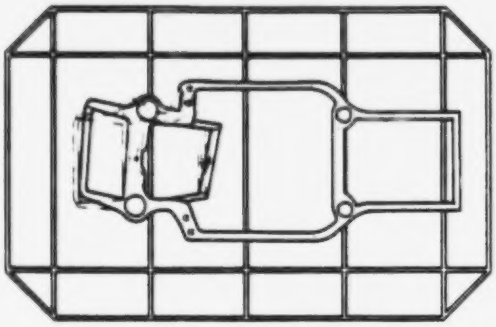
Assignment Sheet 1-1

Damage Type ______________________

____

____

DIAGRAM THE PROPER HOOKUP FOR REPAIR



USE ARROWS FOR PULL PUSH DIRECTION ———→

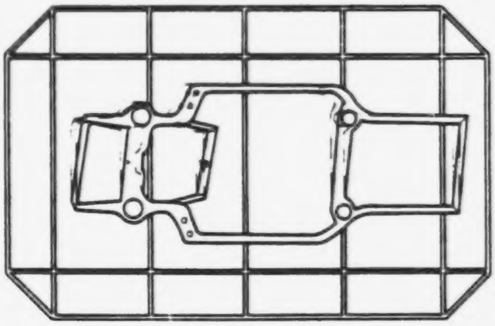
USE STATIC LINES FOR ANCHOR POINTS ———|||

Damage Type ______________________

____

____

DIAGRAM THE PROPER HOOKUP FOR REPAIR



USE ARROWS FOR PULL PUSH DIRECTION ———→

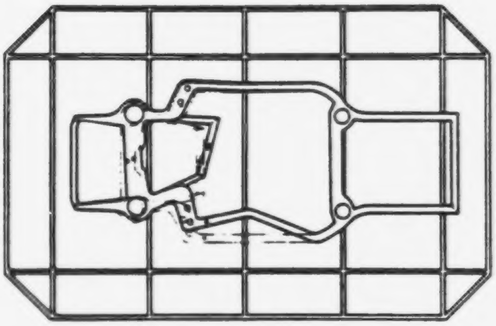
USE STATIC LINES FOR ANCHOR POINTS ———|||

Damage Type ______________________

____

____

DIAGRAM THE PROPER HOOKUP FOR REPAIR



USE ARROWS FOR PULL PUSH DIRECTION ———→

USE STATIC LINES FOR ANCHOR POINTS ———|||

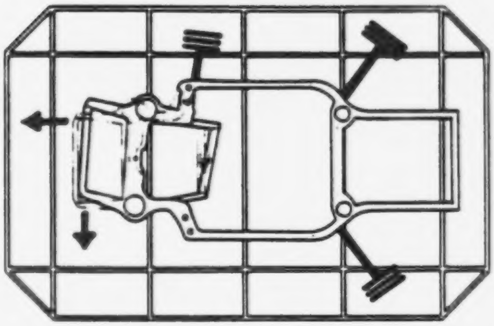
Answers to Assignment Sheet 1-1

Damage Type ______________________

____

____

DIAGRAM THE PROPER HOOKUP FOR REPAIR



USE ARROWS FOR PULL PUSH DIRECTION ——→

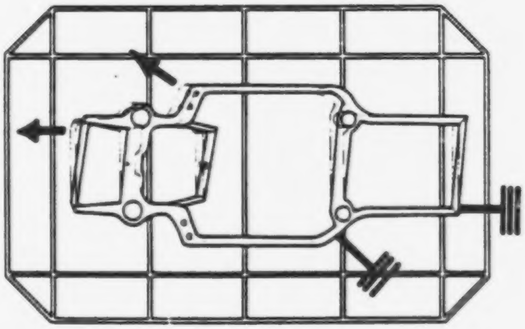
USE STATIC LINES FOR ANCHOR POINTS ——|||

Damage Type ______________________

____

____

DIAGRAM THE PROPER HOOKUP FOR REPAIR



USE ARROWS FOR PULL PUSH DIRECTION ——→

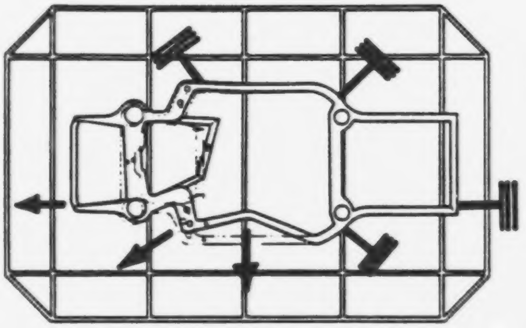
USE STATIC LINES FOR ANCHOR POINTS ——|||

Damage Type ______________________

____

____

DIAGRAM THE PROPER HOOKUP FOR REPAIR



USE ARROWS FOR PULL PUSH DIRECTION ——→

USE STATIC LINES FOR ANCHOR POINTS ——|||

UNIT VIII

JOB SHEET #1, LESSON TWO

PREPARE VEHICLE FOR FRAME REPAIR

Equipment

Vehicle with frame damage
A hoist, jacks, platform stands or any other available equipment that will get the car far enough in the air to perform underbody visual and measurement checks
Measuring equipment (tram and centering gauges, a universal system or a dedicated system)
Anchoring system
Pulling system, including needed clamps or hooks
Equipment and vehicle manufacturer's specifications
Common hand tools needed to disassemble parts from vehicle that may obstruct visual or measurement checks
Miscellaneous equipment such as stools and creepers

Procedure:	**Evaluation:** 3	2	1	N
1. Prepare vehicle for analysis.	___	___	___	___
2. Analyze damage, leaving gauging equipment in place, if possible.	___	___	___	___
3. Plan repair sequence.				
a. Determine pulls required.	___	___	___	___
b. Determine hookup points per vehicle specifications.	___	___	___	___
c. Determine order of pulls.	___	___	___	___
4. Remove required components.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average will be transferred to job sheets 2-6, becoming part of each competency evaluation.)

UNIT VIII

JOB SHEET #2, LESSON TWO

STRAIGHTEN AND ALIGN TWIST DAMAGE

Equipment

Vehicle with twist damage or simulator
Vehicle specifications
Measuring equipment
Anchoring and pulling system
Gas welder
Miscellaneous tools and equipment, such as common hand tools to help disassemble obstructing parts

(NOTE: Because the required procedure will vary according to the equipment available, the vehicle to be repaired and the extent of damage the instructor will explain and demonstrate the exact procedure to the extent instructor determines necessary for safe and successful completion of job)

Procedure:	**Evaluation:** 3	2	1	N
1. Prepare vehicle for alignment by performing Job Sheet #1.	___	___	___	___
2. Anchor vehicle.	___	___	___	___
3. Attach pulling equipment.	___	___	___	___
4. Initiate and complete pulling procedure.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average may be used as the evaluation for competency Y1 "Straighten and align structural damage.")

UNIT VIII

JOB SHEET #3, LESSON TWO

STRAIGHTEN AND ALIGN DIAMOND DAMAGE

Equipment

Vehicle with diamond damage or simulator
Vehicle specifications
Measuring equipment
Anchoring and pulling system
Gas welder
Miscellaneous tools and equipment, such as common hand tools to help disassemble obstructing parts

(NOTE: Because the required procedure will vary according to the equipment available, the vehicle to be repaired and the extent of damage the instructor will explain and demonstrate the exact procedure to the extent instructor determines necessary for safe and successful completion of the job.)

Procedure:	**Evaluation:** 3	2	1	N
1. Prepare vehicle for alignment by performing Job Sheet #1.	___	___	___	___
2. Anchor vehicle.	___	___	___	___
3. Attach pulling equipment.	___	___	___	___
4. Initiate and complete pulling procedure.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average may be used as the evaluation for competency Y1 "Straighten and align structural damage.")

UNIT VIII

JOB SHEET #4, LESSON TWO

STRAIGHTEN AND ALIGN MASH DAMAGE

Equipment

Vehicle with mash damage or simulator
Vehicle specifications
Measuring equipment
Anchoring and pulling system
Gas welder
Miscellaneous tools and equipment, such as common hand tools to help disassemble obstructing parts

(NOTE: Because the required procedure will vary according to the equipment available, the vehicle to be repaired and the extent of damage, the instructor will explain and demonstrate the exact procedure to the extent instructor determines necessary for safe and successful completion of the job.)

Procedure:	**Evaluation:**			
	3	2	1	N
1. Prepare vehicle for alignment by performing Job Sheet #1.	___	___	___	___
2. Anchor vehicle.	___	___	___	___
3. Attach pulling equipment.	___	___	___	___
4. Initiate and complete pulling procedure.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average may be used as the evaluation for competency Y1 "Straighten and align structural damage.")

UNIT VIII

JOB SHEET #5, LESSON TWO

STRAIGHTEN AND ALIGN SAG DAMAGE

Equipment

Vehicle with sag damage or simulator
Vehicle specifications
Measuring equipment
Anchoring and pulling system
Gas welder
Miscellaneous tools and equipment, such as common hand tools to help disassemble obstructing parts

(NOTE: Because the required procedure will vary according to the equipment available, the vehicle to be repaired and the extent of damage, the instructor will explain and demonstrate the exact procedure to the extent instructor determines necessary for safe and successful completion of the job.)

Procedure:	**Evaluation:** 3	2	1	N
1. Prepare vehicle for alignment by performing Job Sheet #1.	___	___	___	___
2. Anchor vehicle.	___	___	___	___
3. Attach pulling equipment.	___	___	___	___
4. Initiate and complete pulling procedure.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average may be used as the evaluation for competency Y1 "Straighten and align structural damage.")

UNIT VIII

JOB SHEET #6, LESSON TWO

STRAIGHTEN AND ALIGN SIDESWAY DAMAGE

Equipment

Vehicle with sidesway damage or simulator
Vehicle specifications
Measuring equipment
Anchoring and pulling system
Gas welder
Miscellaneous tools and equipment, such as common hand tools to help disassemble obstructing parts

(NOTE: Because the required procedure will vary according to the equipment available, the vehicle to be repaired and the extent of damage, the instructor will explain and demonstrate the exact procedure to the extent instructor determines necessary for safe and successful completion of the job.)

Procedure:	**Evaluation:** 3	2	1	N
1. Prepare vehicle for alignment by performing Job Sheet #1.	___	___	___	___
2. Anchor vehicle.	___	___	___	___
3. Attach pulling equipment.	___	___	___	___
4. Initiate and complete pulling procedure.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average may be used as the evaluation for competency Y1 "Straighten and align structural damage.")

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT VIII: DAMAGE REPAIR PROCEDURES

UNIT TEST

I. Mark a T on the test answer sheet if the statement is true or an F if the statement is false.

_____1. When in doubt about whether a vehicle is properly anchored, you should add another anchor.

_____2. A diagram of the impact force should be drawn on a drawing pad.

_____3. All gauging equipment must be removed before initiating a pull.

_____4. When heating mild steel use either heat crayons or do not heat beyond a dark cherry-red.

_____5. Unibody components that will be replaced should be removed prior to beginning the pulling procedure.

_____6. The pressure of the pull should be concentrated into the smallest possible area.

_____7. The best way to avoid overpulling is to measure the progress of each pull after each application of pressure.

_____8. The most accurate way of determining the temperature of a metal is to use a thermoplast.

_____9. Metals heated for stress relief should be cooled by using forced air.

II. Select the best answer from the choices listed.

_____10. Stress relief allows structural steel to return to its original: (a) size and consistency, (b) shape and state, (c) size and shape, (d) state and resiliency, (e) shape and resiliency.

_____11. Stress relief will not work unless: (a) Pressure is applied, (b) pressure is applied in the opposite direction of damage, (c) pressure is applied in the same direction as damage, (d) pressure is applied with proper equipment, (e) enough pressure is applied.

_____12. The objectives of any pull are to restore damaged metal back to original: (a) length, appearance and strength, (b) length, height and width, (c) shape, state and alignment, (d) dimension, strength and state, (e) appearance, shape and alignment.

_____13. If metal has stretch stress on one side, which type of stress will it have on the other side? (a) tension, (b) collapse, (c) compression, (d) distress, (e) heat.

_____14. To perform heat relief you would use: (a) compressed air, (b) oxyacetylene torch, (c) MIG welder, (d) water, (e) a hammer.

III. From the following list, order the steps of procedure in the principal sequence of straightening damage. Question 15 will be the letter of the first step, question 16 the letter of the second step, etc.

_____15.	A.	Anchor vehicle
_____16.	B.	Perform stress relief, if needed
_____17.	C.	Start pull
_____18.	D.	Analyze damage
_____19.	E.	Measure progress
_____20.	AB.	Repeat steps 17 and 18.

(NOTE: Completion of this unit test with a minimum score of _____ is necessary for the student to receive evaluations on the following competencies: Y1 "Straighten and align structural damage," Y2 "Replace component parts," and Y3 "Perform stress relief using shock.")

ANSWERS TO UNIT VIII TEST

1. T
2. T
3. F
4. T
5. F
6. F
7. T
8. F
9. F

10. B
11. B
12. C
13. C
14. B

15. D
16. A
17. C
18. E
19. B
20. AB

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT IX: UNIBODY STRUCTURAL SECTIONING

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to section unibody structural components. Mastery will be evidenced through demonstration and by scoring __________percent on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

Lesson 1:

I. Match terms with their definitions (Competency Y6, Unit IX test)

II. Identify general principles of sectioning (Competency Y6, Unit IX test)

III. Identify the seven principle sections that can be sectioned and the construction of those components (Competency Y6, Unit IX test)

IV. Identify approved welds and welding procedures (Competency Y6, Unit IX test)

V. Demonstrate the ability to:

   a. Section body rails (Competencies Y2, Y5-Y7, Job Sheet #1)

   b. Section rocker panels (Competencies Y2, Y5-Y7, Job Sheet #2)

   c. Section A-pillars (Competencies Y2, Y5-Y7, Job Sheet #3)

   d. Section B-pillars (Competencies Y2, Y5-Y7, Job Sheet #4)

   e. Section floor panels (Competencies Y2, Y5-Y7, Job Sheet #5)

   f. Section trunk floors (Competencies Y2, Y5-Y7, Job Sheet #1)

   g. Section a full body (Competencies Y2, Y5-Y7, Job Sheet #7)

MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT IX: UNIBODY STRUCTURAL SECTIONING

CONTENTS OF THIS UNIT

A. Objective sheet

B. Contents of this unit

C. Notes to the instructor

D. References

E. Lesson plan

  1. Lesson 1: Unibody structural sectioning

    a. Information outline

    b. Job sheets

      JS#1: Section body rails, front and rear
      JS#2: Section rocker panels
      JS#3: Section A-pillars
      JS#4: Section B-pillars
      JS#5: Section floor panels
      JS#6: Section trunk floors/rear panels
      JS#7: Full body sectioning

F. Unit test

G. Answers to unit test

NOTES TO THE INSTRUCTOR

A. Any of the job sheets in this unit will evaluate multiple competencies. Due to the similarity between replacing component parts (Y2) and sectioning component parts (Y6), a sectioning procedure will also serve as the evaluation for replacing component parts. However, Competency J2 "Remove and replace structural panels welded on," in the Panel Repairs Module, would also be the evaluation for Competency Y2 if the procedure was done on a unibody vehicle.

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MODULE: FRAME-BODY AND UNIBODY CONSTRUCTION AND REPAIR

UNIT IX: UNIBODY STRUCTURAL SECTIONING

LESSON 1: UNIBODY STRUCTURAL SECTIONING AND REPAIR

I. **Terms and definitions**

A. Butt weld with insert – Type of weld joint in which two components, usually closed sections, are welded together end-to-end, using an insert for reinforcement and alignment.

B. Butt weld – Type of weld in which two components are joined together end-to-end, without overlap.

C. C-section – A unibody component, which when viewed from the end, is C-shaped, having no flanges.

D. Closed section – Unibody sections with both inside and outside surfaces, usually composed of a hat section welded to a flat surface, two hat sections welded together, or c-sections welded together. Closed sections provide the principal strength in unibody construction.

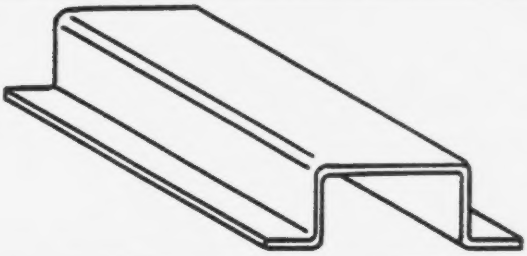
(EXAMPLES: Rocker panels, pillars, front and rear rails)

E. Crush Zone – An area of a structural component in a unibody that is designed to buckle in a collision, absorbing most of the impact energy.

F. Full-body sectioning – Procedure done in cases of severe rear-end collision in which everything is replaced as a unit from the A-pillars back. It involves sectioning the rocker panels, floor pan and A-pillars.

G. Hat Section – Design in which an open, C-shaped or rectangular channel component has the edges flared into parallel flat surfaces on each edge of the open side, making it resemble a hat. (FIG 1-1.)

FIG. 1-1



H. Insert – A short section of steel in the shape of two closed sections to be welded together. It is smaller than the closed sections so that they fit over the insert as sleeves. They must be made of the same type of metal as that being sectioned and they must be held tight against the sections when welding, using sheet metal screws or other means.

I. Open section – Single-layer components with no inside surfaces.

(EXAMPLES: Floor pans and trunk floors)

J. Overlap weld – A type of weld joint in which open-surface components or open-section components are welded so that they are joined surface-to-surface and not end-to-end. (Also known as a lap weld.)

K. Plug weld – Weld used to replace factory spot welds and to secure inserts. Made by drilling a hole in the outer section of the two surfaces to be joined and welding though the hole.

L. Sectioning – Procedure used to replace portions of major structural components in unibody vehicles.

M. Spot Weld – A factory weld in which two opposing surfaces are fused together.

N. Staggered butt weld – A type of weld joint in which two closed sections are welded together in such a way that they have both end-to-end surfaces and overlapping surfaces. Used without an insert. Also known as an offset butt weld.

O. Weld-through primer – Corrosion protection applied to bare metal surfaces prior to being welded together.

II. General principles of sectioning

A. Sectioning means removing and replacing part of a component rather than removing the entire component.

B. There are two types of sectioning

1. Sectioning cosmetic panels
2. Sectioning structural panels

C. Sectioning cosmetic panels is often performed and is much simpler than sectioning structural panels. One cosmetic panel which is frequently sectioned is the quarter panel.

(NOTE: See Module 3: Panels Repairs for procedures used in sectioning cosmetic panels.)

D. Sectioning structural panels has been a controversial procedure, but it is also becoming a widely accepted procedure with major advantages.

E. Advantages of unibody structural sectioning

1. Keeps more corrosion protection intact.
2. Allows the use of recycled parts, in appropriate cases.
3. Makes the repair less costly for insurance companies and motorists by reducing the time needed to perform the job.

F. Structural sectioning is controversial because the repair involves the most critical components in the unibody vehicle -- components which must meet manufacturers' design specifications in order for the vehicle to be "crashworthy."

G. Improper sectioning procedures can weaken the vehicle structure, causing more danger to the passenger compartment in a collision.

H. Improper sectioning procedures can allow corrosion to eat through a sectioned component, causing a dangerous defect in the vehicle that could give way even in normal driving.

I. Vehicle manufacturers have begun to approve structural sectioning procedures for their vehicles, based on their own tests and tests conducted by independent laboratories.

J. Each manufacturer has it's own approved sectioning procedures for each vehicle it produces. It is critical that manufacturers' recommendations be followed for the vehicle being sectioned.

K. Each of seven principle unibody structural components can be sectioned, but not on all vehicles. Again, follow the manufacturers' recommendations.

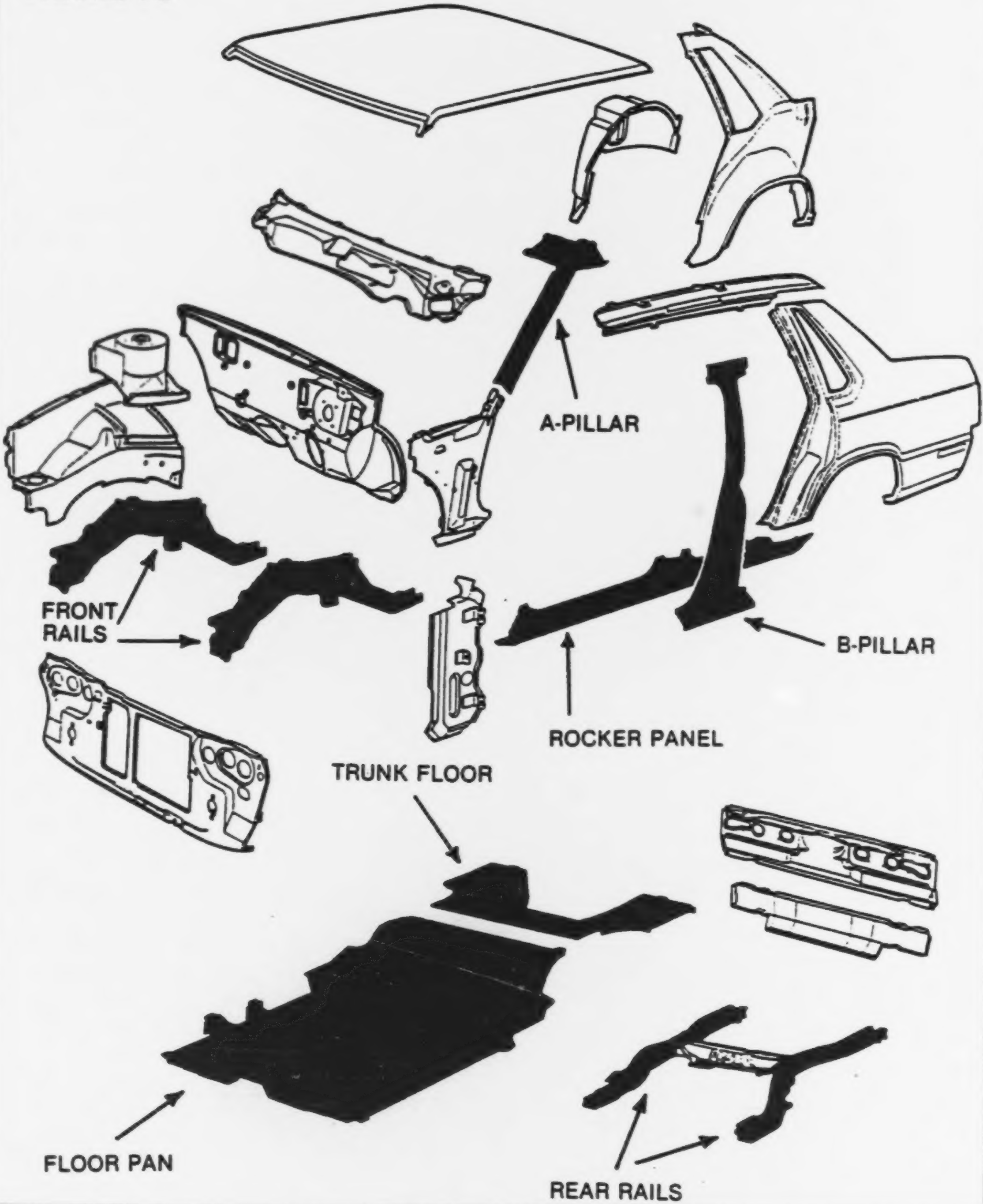
L. Unibody structural sectioning is a procedure that any auto body shop must be able to perform in order to stay competitive in modern vehicle repair. It will continue to become more important and more common due to the pressure from insurance companies to reduce unibody repair costs.

III. Principle structural components of unibody design that can be sectioned (FIG. 1-2)

A. There are seven principle structural components of unibody construction which can be sectioned.

1. Front rails -- Extend from under the floor pan forward toward the front the vehicle, including the apron assembly.
2. Rocker panels -- Form the lower exterior edge of the passenger compartment.
3. Rear rails -- Extend from underneath the floor pan backward toward the rear of the vehicle.
4. B-pillars -- Extend from the center of the rocker panel upward along the outside edge of the passenger compartment. (Also called center pillars.)
5. A-pillars -- Extend upward from the front of the passenger compartment and form the outer edge of the windshield area (Also called windshield pillars.)
6. Floor pans -- Form the bottom of the passenger compartment, extending between the right and left rocker panels.
7. Trunk floors -- Form the bottom of the rear compartment, extending between the rear rails and adjoining the floor pan.

FIGURE 1-2


A-PILLAR
FRONT RAILS
B-PILLAR
ROCKER PANEL
TRUNK FLOOR
FLOOR PAN
REAR RAILS

Adapted with permission of Chrysler Motors

B. The seven structural components above fall into two basic types

  1. Open sections

    a. Trunk floors

    b. Floor pans

  2. Closed sections

    a. Rocker panels

    b. Front and rear rails

    c. A- and B-pillars

C. Welding closed sections is where procedures become critical. Closed sections provide much of the strength of the unibody.

D. Structure of closed sections.

  1. Closed sections are also called box sections. An open section has a top and a bottom surface, but a closed section has an interior surface and an exterior surface.

  2. There are two basic designs of the steel pieces that make up a closed section.

    a. C-sections -- Form a squared-off, or rounded "C" shape with no flanges on the edges.

    b. Hat sections -- Formed by flaring the ends of a c-section, forming flanges.

    (NOTE: Some sections are "half-hat" sections, in that they have only one flared end.)

  3. Closed sections generally fall into three basic constructions

    a. A hat section welded to a flat surface

    (Examples: A rear rail hat section welded to the trunk floor, or a front rail hat section welded to a side rail.)

    b. Two hat sections welded together

    (Example: Most rocker panels)

    c. Two or three c-sections welded together

    (Example: Many front rails and most A- and B-pillars)

  3. In order to properly join sectioned components, certain approved welds must be used. The following welds are approved by the Inter-Industry Conference on Auto Collision Repair. The vehicle manufacturer will have recommendations on which of the welds should be used for specific sectioning procedures.

IV. I-CAR approved welds

A. Overlap weld

1. Used on open sections or hat sections

B. Butt weld

1. Used on closed sections

C. Staggered butt weld

1. Used on closed sections

2. Has greater strength that straight butt weld

(NOTE: When making cuts to make a staggered butt weld, always make the cuts between any factory spot welds.)

D. Butt weld with insert

1. Used on closed sections

2. Provides excellent strength and is recommended for many closed sections, especially those formed by the joining of C-sections as opposed to hat sections.

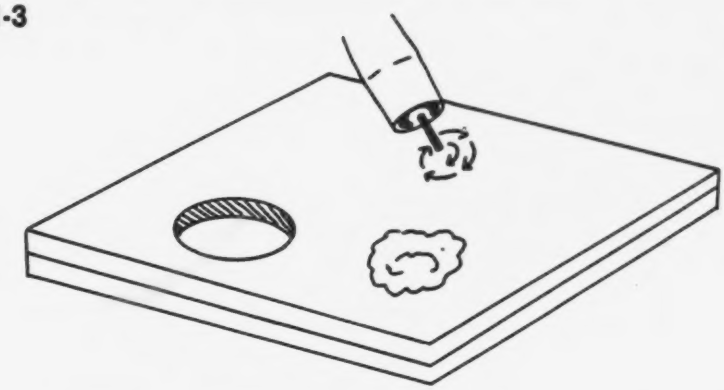
3. The weld should be made such that there is a gap between the sections being joined to allow complete fusion with the insert. The gap should be at least as wide as the welding wire being using and not more than 1/8 inch wide.

4. The insert must be held in place with sheet metal screws or a similar procedures prior to welding.

5. The insert should be secured using plug welds.

E. Approved welding procedures (FIG. 1-3)

FIGURE 1-3



1. Plug welds

   a. Used to replace factory spot welds.

   b. Made by cutting a 5/16 hole (unless another size hole is recommended) in the outer panel of two surfaces to be joined and welding through the hole.

   c. Weld is made with a slow, circular motion of the welding tip.

   d. Plug welds should be no closer together than twice the diameter of the hole drilled for the weld.

2. Stitch welds

   a. Used to control heat distortion while making a continuous weld.

   b. May be made by welding a short section, then skipping a short section, or by using the stitch weld function on many welders.

   (NOTE: See Module 2: "Auto Body Welding," for a more complete discussion on welding techniques and procedures.)

3. Continuous welds

   a. Done when a continuous weld is desired and heat distortion is not a problem.

   b. Should be done only if recommended.

   (NOTE: All welds must produce a weld in which the sections are joined completely, with absolutely no gaps.)

E. Making an overlap weld

(NOTE: Again, in making any of these welds, consult vehicle manufacturers recommendations.)

1. Join surfaces with recommended overlap.

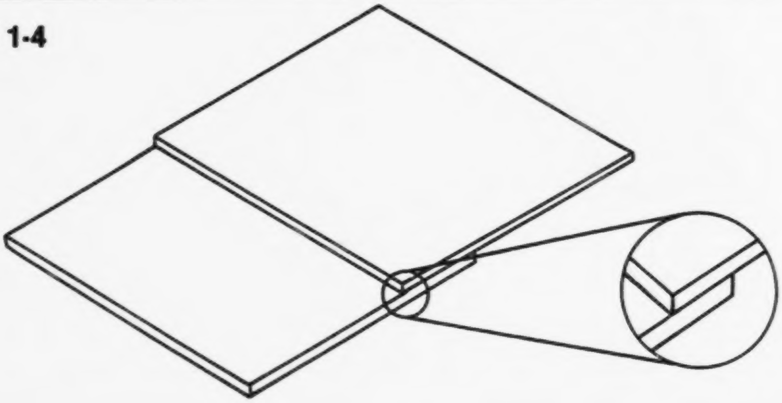
2. Weld seams continuously or with stitch weld as recommended.

3. When welding floor pans or trunk floors, special procedures must be followed.

   1. The overlap must be made such that the front section is underneath the rear section. This causes less stress on the weld from moisture and road hazards. (FIG. 1-4)

   2. A seam sealer, primer and topcoat must be applied to the weld to prevent exhaust gas leaking into the passenger compartment or trunk compartment.

FIGURE 1-4



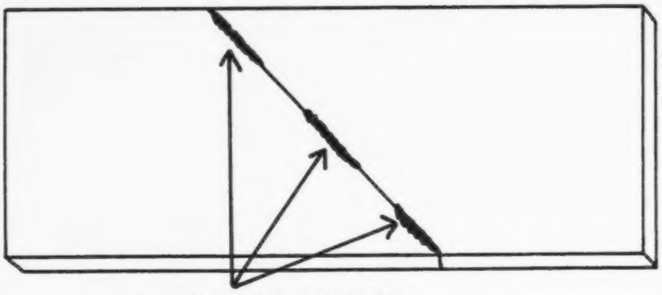
F. Making a butt weld

1. Join surfaces end to end.

2. Be especially careful to make weld completely, with no gaps.

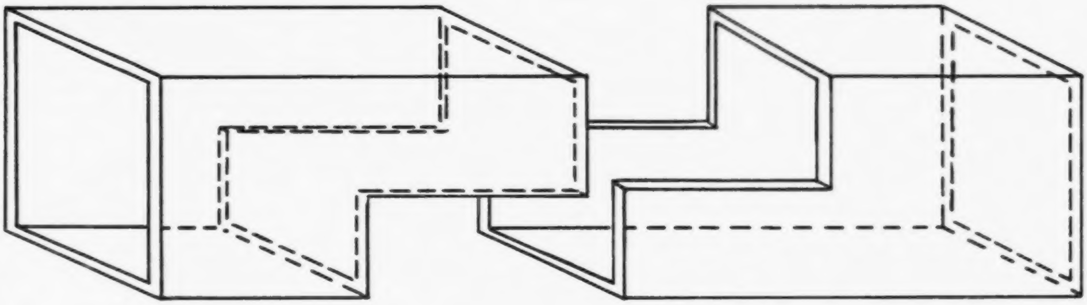
3. Do not make a vertical butt joint on a horizonal section (cut butt joint at an angle). (FIG. 1-5)

FIGURE 1-5



G. Making an offset butt weld (FIG. 1-6)

FIGURE 1-6

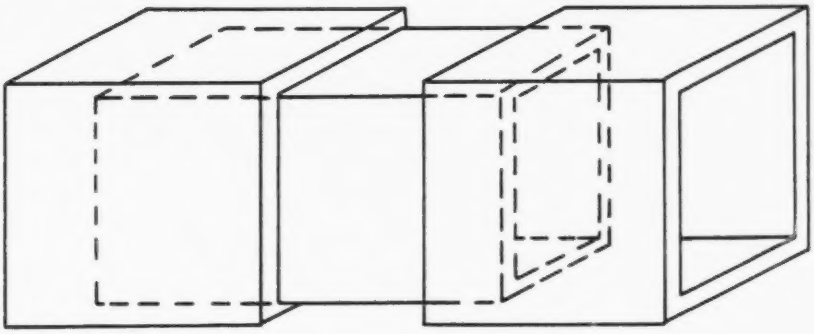


1. Cut sections to be joined such that you have end-to-end and surface-to-surface areas.

2. Be especially careful to leave no gaps.

H. Making a butt weld with insert (FIG. 1-7)

FIGURE 1-7



1. Make an insert from the same material, in the same shape as the parts being joined.

2. Make insert slightly smaller than parts so it will fit inside parts.

3. Use plug welds to secure insert before welding seams.

I. Welding procedures

1. The most critical factor in structural sectioning is making proper welds.

2. A MIG welder must be used and the operator must be skilled in its use.

3. Welds must be protected from corrosion by using approved weld-through primers.

4. In making welds the welding wire used must meet American Welding Society standard AWS-EX-70-S-6 using 75% C02 - 25% argon, or a comparable approved gas mixture.

5. Avoid certain areas in cutting sections

    a. Avoid areas where it will be difficult to gain the access needed to make a proper weld.

    b. Avoid reinforced areas (two thickness of metal).

    c. Avoid crush zones.

    d. Avoid holes in components.

       (NOTE: Holes are often control points which must be maintained for measuring vehicle dimensions.)

    e. Avoid reinforcements for suspension anchors and seat belt anchors. (When sectioning B-pillars, make the cut below the shoulder belt restraint anchor mount low enough to avoid cutting through restraint anchor reinforcement.)

6. Crush zones

    a. Crush zones are areas of the vehicle specifically designed to buckle first in a collision, thereby managing the force of the collision.

    b. Crush zones are critical because they are part of the concept of energy management -- which is designing vehicles in such a way that the forces in a collision are routed away from the passenger compartment.

    c. Crush zones are typically formed from making large holes in the components, convoluted areas or accordioned areas.

    d. Crush zones are present in all frame rails. In all components they are usually ahead of the front suspension and behind the rear suspension.

F. Making test welds

1. In order to assure a quality weld on closed sections, where the other side of the weld cannot be seen, test welds must be made.

2. In making a test weld scrap parts are selected which will duplicate the conditions of the weld which will be done. This is best done by using scraps left over from trimming the sections to be welded.

3. The settings on welder are selected and the weld is made following approved procedures.

4. The test weld is then examined for proper penetration of the back-side and the strength and quality of the weld are examined.

5. If the test weld is successful then the actual weld takes place, using the exact same settings on the welder and the exact same techniques.

G. As with all welding procedures, all safety requirements must be met regarding eye protection, skin protection, the danger of electrical shock, and the dangers inherent in using Mig welding wire and MIG welding shielding gasses. All safety procedures outlined in Module 2: "Auto Body Welding," must be followed. Be especially aware of the danger of harmful fumes produced by coatings on the metal being welded.

H. Metal preparation for sectioning

1. As with all welding procedures, correct preparation of the metal to be welded is critical to the success of the weld. The surfaces to be joined must be thoroughly cleaned.

2. The recommended procedure is to use a wire brush and/or scraper and oxyacetylene torch, keeping the metal at a low, controlled heat.

3. The scraper and torch can be used to remove undercoatings, rustproofing, tars, sealants and other contaminants from accessible areas.

4. The wire brush and torch (using a carburizing flame) can remove plastic filler, lead, rustproofing, paint and other contaminants from the inside of closed sections.

5. Remove all corrosion by sanding or, if recommended, with a power wire brush.

6. Always create a clean surface for the welding ground clamp.

7. The Inter-Industry Conference on Auto Collision Repair recommends that when welding galvanized or zinc-coated steels, the zinc must not be removed. Grinding away the zinc reduces the strength and thickness of the metal and creates a target for corrosion.

8. If using recycled parts make sure that the recycled parts are of good quality, with no corrosion.

9. If using recycled parts the parts should not be cut with an oxyacetylene torch. If the parts must be cut with an oxyacetylene torch, then allow two extra inches on section lengths for heat distortion

I. Finding and using manufacturers recommendations.

1. The recommendations of manufacturers are available from the manufacturer for all vehicles, often in the form of supplemental publications such as Ford's "Body Repair Tips."

2. The recommendations will tell exactly which procedures to follow for which vehicle in sectioning components.

3. The recommendations will show the location and type of welds to be made, the exact locations for cutting out the damaged section, and the exact areas to trim the replacement section.

4. The recommendations will give tips on how to best perform the sectioning procedures.
5. The recommendations will also tell exactly the type of metal, heat ranges for the metal and other important factors in proper sectioning.

UNIT IX

JOB SHEET # 1, LESSON ONE

SECTIONING BODY RAILS, FRONT AND REAR

Equipment

Factory specifications for vehicle
MIG welder and equipment
Measuring equipment
Anchoring and pulling equipment
Appropriate tools for removal of mechanical components
Appropriate cutting equipment
Appropriate corrosion protection
Protective clothing and eyewear

Procedure:	**Evaluation:** 3	2	1	N
1. Remove any necessary mechanical components.	___	___	___	___
2. Straighten secondary damage to factory specs.	___	___	___	___
3. Determine area to be replaced.	___	___	___	___
4. Remove damaged section.	___	___	___	___
5. Trim replacement section.	___	___	___	___
6. Weld replacement section (use appropriate technique below.)	___	___	___	___
a. For closed section, replace entire assembly section by welding butt joint per I-CAR standards, using weld-through primers (for partial section replacement, use butt joint with insert.)				
b. For open sections replace entire assembly to matching flange using plug welds to replace factory spot welds and applying weld-through primers (for partial section, use lap joint with plug welds in overlap areas and continuous lap welds).				
7. Apply corrosion protection.	___	___	___	___

8. Re-install mechanical components and complete repairs. — — — —

Average of above evaluations* — — — —

(*This average may be used as the evaluation for competencies Y2 "Replace component parts," Y5 "Replace high strength steel," Y6 "Section component parts," Y7 "Remove and reinstall mechanical components.")

UNIT IX

JOB SHEET # 2, LESSON ONE

SECTIONING ROCKER PANELS

Equipment

Factory specifications for vehicle
MIG welder and equipment
Measuring equipment
Anchoring and pulling equipment
Appropriate tools for removal of mechanical components.
Appropriate cutting equipment
Appropriate corrosion protection
Protective clothing and eyewear

Procedure:

Evaluation:
3 2 1 N

1. Remove any necessary mechanical components. ___ ___ ___ ___
2. Straighten secondary damage to factory specs. ___ ___ ___ ___
3. Determine area to be replaced. ___ ___ ___ ___
4. Remove damaged section. ___ ___ ___ ___
5. Trim replacement section. ___ ___ ___ ___
6. For cars with B-pillars, trim and overlap joint used at B-pillar. ___ ___ ___ ___
7. Weld replacement section (using appropriate technique below). ___ ___ ___ ___
   - a. For complete section, outer
     - (1) Remove at factory seams.
     - (2) Trim and fit panel.
     - (3) Use same number of welds in the same location using weld-through primers.
   - b. For partial sections, straight cut butt joint with insert
     - (1) Trim and fit panel.
     - (2) Build insert.
     - (3) Drill holes for plug welds.

(4) Apply weld-through primers.

(5) Perform butt welds and plug welds in joint. Perform plug welds in same location as original factory pinchwelds.

c. For partial sections with overlap joint

(1) Trim and fit panel.

(2) Drill holes for plug welds.

(3) Apply weld-through primers.

(4) Perform lap welds and plug welds in joint. Perform plug welds in same location as original pinchwelds.

8. Apply corrosion protection. — — — —

9. Re-install mechanical components and complete repairs. — — — —

Average of above evaluations* — — — —

(*This average may be used as the evaluation for competencies Y2 "Replace component parts," Y5 "Replace high strength steel," Y6 "Section component parts," Y7 "Remove and reinstall mechanical components.")

UNIT IX

JOB SHEET #3, LESSON ONE

SECTIONING WINDSHIELD/A-PILLARS

Equipment

Factory specifications for vehicle
MIG welder and equipment
Measuring equipment
Anchoring and pulling equipment
Appropriate tools for removal of mechanical components
Appropriate cutting equipment
Appropriate corrosion protection
Protective clothing and eyewear

Procedure:	**Evaluation:** 3	2	1	N
1. Remove any necessary mechanical components.	___	___	___	___
2. Straighten secondary damage to factory specs.	___	___	___	___
3. Determine area to be replaced.	___	___	___	___
4. Trim and fit replacement panel.	___	___	___	___
5. Weld replacement section (using appropriate technique below.)	___	___	___	___

(Note: Protect exterior and interior trim from splatter.)

a. For straight cut butt joint with insert

(1) Remove damaged section.

(2) Measure and make cut in center of pillar, if possible.

(3) Remove replacement section.

(4) Build insert.

(5) Drill holes for plug welds.

(6) Apply weld-through primers.

(7) Perform butt welds and plug welds in joint area.

Procedure: **Evaluation:**

3 2 1 N

b. For offset butt joint

(1) Make offset butt joint cuts at different points on the inner panel section and outer panel section.

(2) Remove appropriate spot welds from pinch welds and remove damaged section (make sure cuts are no closer than two inches and no farther apart than four inches).

(3) Apply weld-through primers.

(4) Position and weld continuous butt welds.

(5) Make plug welds at original spot weld locations.

5. Apply corrosion protection. ____ ____ ____ ____

6. Re-install any mechanical components and complete repairs. ____ ____ ____ ____

Average of above evaluations* ____ ____ ____ ____

(*This average may be used as the evaluation for competencies Y2 "Replace component parts," Y5 "Replace high strength steel," Y6 "Section component parts," Y7 "Remove and reinstall mechanical components.")

UNIT IX

JOB SHEET # 4, LESSON ONE

SECTIONING B-PILLARS/CENTER PILLARS

Equipment

Factory specifications for vehicle
MIG welder and equipment
Measuring equipment
Anchoring and pulling equipment
Appropriate tools for removal of mechanical components.
Appropriate cutting equipment
Appropriate corrosion protection
Protective clothing and eyewear

Procedure:	**Evaluation:** 3	2	1	N
1. Remove any necessary mechanical components.	___	___	___	___
2. Straighten secondary damage to factory specs.	___	___	___	___
3. Determine area to be replaced.	___	___	___	___
4. Remove damaged section (When recycled parts are used, rocker panel and B-pillar may be put in as one unit. Also, when sectioning B-pillar make cut below restraint anchor mount.	___	___	___	___
5. Weld replacement section (using appropriate technique below.)	___	___	___	___

- a. For straight cut butt joint with insert
    - (1) Remove damaged section.
    - (2) Measure and cut in center of pillar, if possible.
    - (3) Trim replacement section.
    - (4) Build insert.
    - (5) Drill holes for plug welds.
    - (6) Apply weld-through primers.
    - (7) Perform butt welds and plug welds in joint area.

Procedure:

Evaluation:
3 2 1 N

b. For offset butt joint

  (1) Make offset butt joint cut at different points on the inner panel section and outer panel section.

  (2) Remove appropriate spots welds from pinch welds and remove damaged section (make sure cuts are no closer than two inches and no farther apart than four inches).

  (3) Apply weld-through primers.

  (4) Position and weld continuous butt welds.

  (5) Make spot welds at original locations.

6. Apply corrosion protection. ___ ___ ___ ___

7. Re-install any mechanical components and complete repairs. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average may be used as the evaluation for competencies Y2 "Replace component parts," Y5 "Replace high strength steel," Y6 "Section component parts," Y7 "Remove and reinstall mechanical components.")

UNIT IX

JOB SHEET # 5, LESSON ONE

SECTIONING FLOOR PANELS

Equipment

Factory specifications for vehicle
MIG welder and equipment
Measuring equipment
Anchoring and pulling equipment
Appropriate tools for removal of mechanical components.
Appropriate cutting equipment
Appropriate corrosion protection
Protective clothing and eyewear

Procedure:

Evaluation:
3 2 1 N

1. Remove any necessary mechanical components. ___ ___ ___ ___
2. Straighten secondary damage to factory specs. ___ ___ ___ ___
3. Determine area to be replaced. ___ ___ ___ ___
4. Remove damaged section at pre-measured location allowing 1-inch overlap on single-thickness metal only. ___ ___ ___ ___
5. Trim replacement section. ___ ___ ___ ___
6. Weld replacement section using procedure below. ___ ___ ___ ___
    a. Be sure rear section overlaps front section so edge of front section is on bottom.
    b. Drill 5/16 holes in top section for plug welds (approximately 1-inch spacings on welds).
    c. Use weld-through primers.
    d. Plug weld top section. Use continuous lap weld on bottom seam.
7. Use appropriate seam sealers on welds and prime. ___ ___ ___ ___

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
8. Re-install mechanical components and complete repairs.	___	___	___	___
Average of above evaluations*	___	___	___	___

(*This average may be used as the evaluation for competencies Y2 "Replace component parts," Y5 "Replace high strength steel," Y6 "Section component parts," Y7 "Remove and reinstall mechanical components.")

UNIT IX

JOB SHEET # 6, LESSON ONE

SECTIONING TRUNK FLOORS/REAR PANELS

Equipment

Factory specifications for vehicle
MIG welder and equipment
Measuring equipment
Anchoring and pulling equipment
Appropriate tools for removal of mechanical components.
Appropriate cutting equipment
Appropriate corrosion protection
Protective clothing and eyewear

Procedure:

Evaluation:
3 2 1 N

1. Remove any necessary mechanical components. ___ ___ ___ ___
2. Straighten secondary damage to factory specs. ___ ___ ___ ___
3. Determine area to be replaced. ___ ___ ___ ___
4. Remove damaged section at pre-measured location allowing one-inch overlap on single-thickness metal only. ___ ___ ___ ___
5. Trim replacement section. ___ ___ ___ ___
6. Weld replacement section using procedure below. ___ ___ ___ ___
    a. Be sure rear section overlaps front section so edge of front section is always on bottom.
    b. Drill 5/16 holes in top section for plug welds (approximately one inch spacings on welds).
    c. Use weld-through primers.
    d. Plug weld top section. Use continuous lap weld on bottom seam.

Procedure: **Evaluation:**
3 2 1 N

e. Where possible, section over rear cross member above cross member's rear flange or at factory seams.

(NOTE: On bottom edge, you will not have to make lap weld because of strength provided by cross member.)

7. Use appropriate seam sealers on welds and prime. ____ ____ ____ ____

8. Re-install mechanical components and complete repairs. ____ ____ ____ ____

Average of above evaluations* ____ ____ ____ ____

(*This average may be used as the evaluation for competencies Y2 "Replace component parts," Y5 "Replace high strength steel," Y6 "Section component parts," Y7 "Remove and reinstall mechanical components.")

UNIT IX

JOB SHEET # 7, LESSON ONE

FULL BODY SECTIONING

Equipment

Factory specifications for vehicle
MIG welder and equipment
Measuring equipment
Anchoring and pulling equipment
Appropriate tools for removal of mechanical components.
Appropriate cutting equipment
Appropriate corrosion protection
Protective clothing and eyewear

Procedure:	**Evaluation:**			
	3	**2**	**1**	**N**
1. Remove any necessary mechanical components.				
2. Straighten secondary damage to factory specs.				
3. Determine area to be replaced.				
4. Remove damaged section, after measuring and recording critical dimensions.				
5. Trim replacement section to fit.				
6. Section A-pillars according to Job Sheet #3.				
7. Section rocker panel according to Job Sheet #2, partial section.				
8. Section floor panel according to Job Sheet #5.				
9. Re-install mechanical components and complete repairs.				
Average of above evaluations*				

(NOTE: Factory specifications must be met using some type of measuring system for body alignment.)

(*This average may be used as the evaluation for competencies Y2 "Replace component parts," Y5 "Replace high strength steel," Y6 "Section component parts," Y7 "Remove and reinstall mechanical components.")

UNIT IX TEST

UNIBODY STRUCTURAL SECTIONING

I. Match the terms in the left column with the most closely associated definition or illustration in the right column.

_____1. Butt joint with insert

_____2. Crush zone

_____3. Hat section

_____4. Open surface components

_____5. Plug weld

_____6. Weld-through primer

A. Replaces factory pinch welds and spot welds

B. Floor pans, trunk floors

C. Corrosion protection

D. D-ring

E. Absorbs impact energy in a collision

AB. C-section with flaired edges

AC. Reinforced weld on closed sections

II. Mark on the answer sheet the best answer to each question from the five choices listed.

_____7. The two unibody structural components which are not closed sections are: (a) A-pillars and b-pillars, (b) Floor pans and trunk floors, (c) Front and rear rails, (d) Rocker panels and floor pans, (e) A-pillars and rear rails.

_____8. Plug welds should be made with a: (a) Oxyacetylene welder, (b) Hammer and chisel, (c) Circular motion, (d) 7/16 inch hole, (e) Heat crayon.

_____9. The unibody section which must be covered with a primer, seam sealer and a top coat when sectioned is the: (a) Floor pan, (b) A-pillar, (c) Trunk floor, (d) Body rail, (e) Rocker panel.

_____10. Which of the following is not an area that must be avoided when sectioning: (a) Quarter panels, (b) Anchor points, (c) Holes in components, (d) Crush zones, (e) Reinforced areas.

_____11. Which of the following is not acceptable for use in preparing steel for welding: (a) Wire brush, (b) Sander, (c) Oxyacetylene torch, (d) Solvents, (e) Scraper.

_____12. In making a test weld you: (a) Use I-CAR approved sample metals, (b) Use sample parts and duplicate conditions, (c) Weld at 800 psi, (d) Use an oxyacetylene torch, (e) Consult specifications.

_____13. When making plug welds, the size of the hole drilled is: (a) 3/16 inch, (b) 1/4 inch, (c) 5/16 inch, (d) 3/8 inch, (e) 1/2 inch.

_____14. When making plug welds, the holes should be no closer together than: (a) 1/4 inch, (b) 5/16 inch, (c) 3/8 inch, (d) 1/2 inch, (e) 5/8 inch.

(NOTE: Completion of this test with a minimum score of _________ is necessary for the student to receive an evaluation on Competency Y6 "Section component parts.")

ANSWERS TO UNIT TEST

1. AB
2. E
3. AC
4. B
5. A
6. C

7. B
8. C
9. A
10. A
11. D
12. B
13. C
14. E